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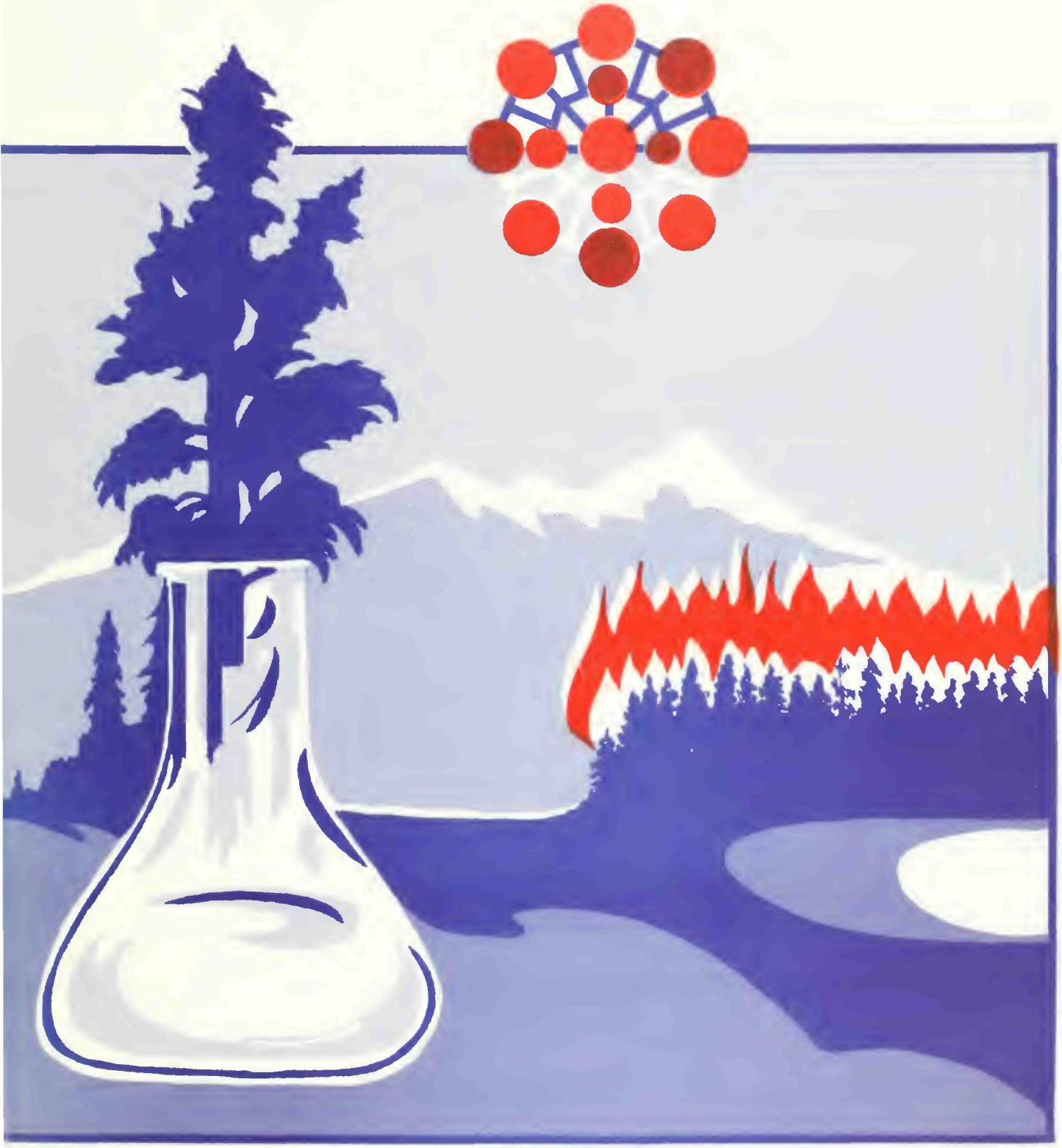
Trends in Research and Applied Technology



Explore New Happenings in Park Management and Operations with Trends

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Contents

Trends in Research and Applied Technology

Volume 19 Number 4 1982

Trends

A publication of the Park Practice Program

The Park Practice Program is a cooperative effort of the National Park Service and the National Recreation and Park Association.

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The Park Practice Program includes:

Trends, a quarterly publication on topics of general interest in park and recreation management and programming; *Grist* a bimonthly publication on practical solutions to everyday problems in park and recreation operations including energy conservation, cost reduction, safety, maintenance, and design for small structures; *Design*, a quarterly compendium of plans for park and recreation structures which demonstrate quality design and intelligent use of materials.

Membership in the Park Practice Program includes a subscription to all three publications and a library of back issues arranged in binders with indices and all publications for the remainder of the calendar year.

The initial membership fee is $80; annual renewal is $20. A separate subscription to *Trends* is $15 initially, and $10 on renewal. Subscription applications and fees, and membership inquiries should be sent *only to:* National Recreation and Park Association, 3101 Park Center Drive, Alexandria, VA 22302.

Articles, suggestions, ideas and comments are invited and should be sent to the Park Practice Program, Division of Cooperative Activities, National Park Service, Washington, D.C. 20240.

PARK • PRACTICE • PROGRAM
1957 1982
Twenty-Fifth Anniversary

Point of View. . .

by Frank C. Goodell, Manager
Park Practice Program

This is the first time *Trends* has addressed the provocative subject of "Research and Applied Technology."

The idea was clearly sparked by Bill Forrey who, if you don't already know him, will be introduced to you quickly in the following introductory pages. I confess to having been taken by surprise when Bill, a very *practical* man, first proposed the topic for *Trends*. I would have expected the suggestion from a park scientist or a science/technology program researcher or staff specialist. But from a general manager? A State Park Director? Research and Applied Technology? Come on now. . .

From the start of our exploration the logic of securing Jean Matthews as a Special Editor for the National Park Service on the staff of the Pacific Northwest Regional Office in Seattle, and a prolific writer with solid credentials in this technical field of park science and technology, we reasoned that her work on this *Trends* issue would not only enhance the product, but would be complementary to her ongoing assignments as well. Fortunately, Jean was willing and her management concurred in the compatibility point of view.

We hope you will agree with us on the approach we have taken, and with the timeliness of this issue on *Research and Applied Technology*.

Marshgrass transplants with the tire mattress in background (Plumb Beach, NY).

National Park Service

Introduction:

by Jean Matthews
Guest Editor

Applied research and applied technology are two different things. Applied technology consists mainly of putting to work the hardware that has emerged from research. Technology is tangible, concrete, almost always a *user* of energy.

Applied research need be none of these things. The computer-age name for the category into which applied research fits is "software," in the sense that it very often consists of nothing more (nor less) than the application of intelligence in an intelligent *way*. It can refer more to process than to product; often it saves, rather than uses, energy.

This issue of *Trends* deals with management applications of research. It does so by describing them as they are affecting park management and interpretive processes. Many a park manager has expressed the intuitive notion that "there may be something to research" in the field of park practices, but at the same time has found the concept slippery to define, difficult to propose, and next to impossible to justify in terms of monetary support.

Yet a backward look is enough to suggest that park problems are constantly evolving and that they do this without any effort on the part of management to make them happen. Certain of these developing problems eventually become impossible NOT to deal with--again, all of their own accord. Given this tendency of events to deteriorate into situations that make expenditures a justifiable "must" in any park budget, the rationale for *anticipating* and *heading off* these developing problems takes on the aura of economic common sense.

Stated thusly, in the abstract, taxpayers and budget directors can be understandably skeptical. That is why this issue of *Trends* came to be: to clothe the preceding paragraphs in the substance of current park practices that stem from research and that are paying their way--in preservation of overall life quality, in the manufacture of human enjoyment, in the saving of energy and dollars, and in the perpetuation of our nation's recreation resource base.

This issue is about research and the applications parks can make of research findings. Some of the results described in these pages are applicable at once, in the same or only slightly altered form, in almost any park situation. Others may be immediately applicable today only in the large natural parks, but their applications nevertheless hold profound implications for change in the small parks and at the general public level.

In several cases, the focus is on new applications of old research knowledge, coming into use in response to new social and economic conditions. In a sense, they are new practices growing out of old information in response to emerging (and still empty) "niches" in the human ecological landscape. (The idea of social *needs* giving rise to new social *forms* is a valid one, based on the ecological principle most often stated as "Nature abhors a vacuum.")

In these pages, a scientist describes the profound management implications growing out of a particular animal research project that some managers felt had long outlived its proper lifespan. As the findings piled up, early indications as to the proper management tack were totally reversed, suggesting that some research may resemble a good recipe: it needs to stay in the oven till it's done.

You will learn how a thoughtful scientist paid attention to the known but little publicized dangers of wood burning; how he sought a remedy for those dangers in another known but little used science–oxidative catalysis, and how these two "little knowns" have put us on the brink of a breakthrough in energy efficiency and pollution control. Already this knowledge is being experimented within the National Park Service's National Capital Region. Eventually it may well impact on the wider social scene.

Some of the research handled here is in the area of social change itself. What is happening in our human society, its economy, its demographics, its energy sources and its behavior patterns, and how are all these changes affecting park usage and the attitudes of both users and managers of parks? How can knowledge of visitors'characteristics help management provide the most appropriate recreation and interpretive programs? Visitor behavior, when observed and recorded by social scientists, often can furnish clues about how to approach resource use problems, as two authors here demonstrate.

This is an issue about how science-guided training has instilled pride and professionalism in a dedicated band of volunteers at one state park and immeasurably enriched the experience of all who use them. At this park, science is being used in the interests of topnotch inter-

pretation which, in turn, enhances public enjoyment and appreciation of the park, its roots, its uses, and the visitor's own rule in the park's funding and future. Not a bad goal for management!

First came man's "quest for fire," then came his quest for fire control. Parks often must deal with the scary matter of fire out of control—fires that lead to loss of property and life, and eventually to research. We look at both sides of the fire-related actions. One side is the wind-whipped firestorm that charred thousands of acres and took the lives of two fire fighters; the other deals with the design of fire programs for parks.

Not many park managers are faced with the mechanical problems of how to treat an endangered species, but those who are lean heavily on scientists for their "way to go." One such account appears in these pages, and perhaps nowhere is the teaming of science and management more immediately and vitally effective than in this mission.

The same kind of team effort, only aimed at the longer haul, is the cooperation between park management and scientists in the paired areas (natural areas and manipulated areas) that constitute World Biosphere Reserves. These areas—36 of them in the United States alone—are preponderately located in National Parks and Forests. Within their confines we are, as a nation, at last inquiring seriously into the innermost workings of the planetary life support systems. These systems constitute the "safety net" that ultimately underlies every human endeavor, every facet of the human condition. The boundaries of meaning for research of this kind tend to erase all distinctions between parks and the world in which they exist.

In short, this is an issue about science and management in the natural and the societal areas, with the merest smattering of examples of how richly rewarding such a pairing can be. It should be read with the idea that it is largely suggestive, and that there rarely has been a time when science stood more readily available to the needs of those who would apply its findings.

The issue ends with a listing of sources for more information. The source listings too should be considered not as comprehensive, but as clues to scientific help in other fields that may be of more immediate interest to you, the reader.

Universities are a rich resource for scientific consultation and help. The National Park Service's university connection-through the Cooperative Park Studies Units (CPSU's)—is explored as an open door for the park managers with problems larger than their park staffs and budgets can handle. So to the list of sources-of-help should be added all the colleges and universities within your access area.

Scientific research is a term that needs to come out of the dusty closet of esoterica and stand at attention before the problems of managing today's world. In this issue of *Trends* we try to help this happen. And now, a word from one of our sponsors. . .

Volunteer and paleontology student Grace Rickard works on mammoth vertebra.

Anza-Borrego Desert State Park

William C. Forrey, President
National Society for Park Resources
National Recreation and Park Association

The subject of this issue of *Trends*—Research and Applied Technology—has generated enormous interest from researchers as well as from the immediate beneficiaries—park managers and directors. The decision to address the subject in *Trends* came about as a result of expressed anxiety from management over increasing problems of mounting complexity—problems with resources and problems with people who use them. In my current position and past work with the National Society for Park Resources, I have been aware of this growing interest and also of the dearth of good periodical literature in this topical area, and I am pleased that the Park Practice staff decided to devote this issue of *Trends* to an exploration of the subject.

The application of research as it relates to field management is a necessary element of our profession; all too often it is relegated to a lower priority. The Board of Directors of NSPR felt that this low priority probably reflected uncertainty as to *how* to proceed in using research. We saw wisdom in the idea of utilizing *Trends* as a forum for presenting research efforts that have direct application to field problems.

Availability for data such as that discussed in these pages can be a valuable aid in carrying out the missions of park agencies. In the long run, the ultimate beneficiaries of more interaction among the scientists and park managers will be the parks themselves, and the people who visit them.

Bill Forrey is the Director, Bureau of State Parks, Pennsylvania Department of Environmental Resources. A long-time advisor and advocate of the Park Practice Program, Bill Forrey is currently a member of the Park Practice Oversight Committee that offers policy guidance and external support for the Program.

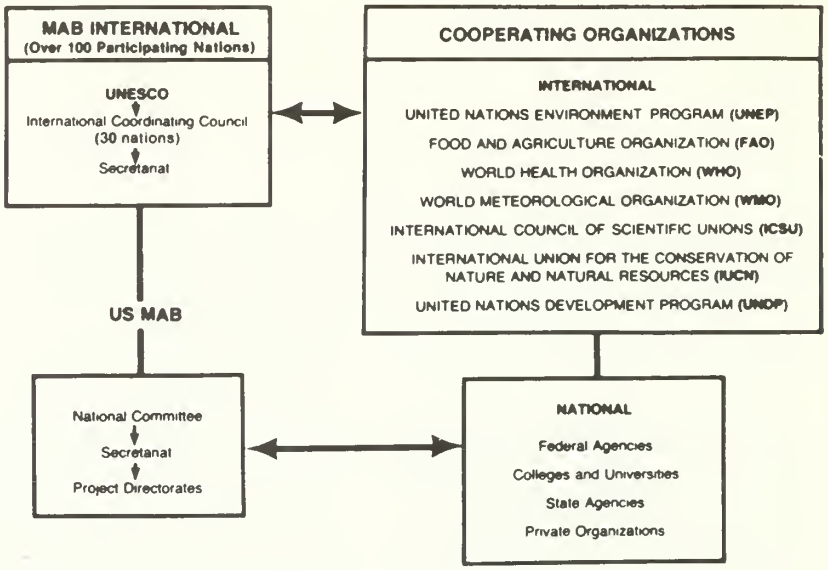
An electric utility cart proved effective as a means for evenly distributing chemicals in Constitution Gardens Lake.

National Park Service

National Park Service, Man and the Biosphere and Natural Resources

by Christine Schonewald-Cox

Man and the Biosphere Program



Air, water and habitat quality are rapidly being degraded, concomitant changes in climate are appearing, and biological diversity is declining at a rate faster than man has been able to plan for the protection of natural resources. The National Park Service is at work with MAB, the International Program of Man and the Biosphere, to improve its own and the global condition.

Tropical forests are being harvested at a rate of 10-20 million hectares per year in tropical countries. Subsequent to harvesting of forests and overgrazing, soils erode and deserts spread. In 1981, the Council on Environmental Quality (CEQ) published a report, *Environmental Trends*, in which it examines the demographic, environmental and biological changes in the United States and North America.

Equally dramatic changes are occurring in North America as are occurring in the tropics. Over 140 million acres of U.S. cropland are eroding. Three-fourths of the 170 million acres of existing rangeland are in only fair to poor condition. In North America 111 million square miles of arid lands (less than 20 inches of precipitation per year) have turned to desert in the last 100 years; 10,500 square miles are undergoing severe desertification; 225 million acres of the severe or very severe desertification is limited to the United States—10 percent of this country's land mass.

The volume of our wetlands has decreased by nearly half since the mid-1950's at a rate of 6,000 acres per year. This is the habitat upon which our waterfowl and fisheries depend for the base of their food chain and for nesting habitats. From 1900-1960, 24 species of vertebrates have become extinct in the United States. The current rate of extinction is 20+ vertebrates per 100 years—estimated to be 7 times the extinction rate of the late pleistocene period.

World population continues to grow. In the U.S. we number 220 million; by the year 2000 we expect to reach 260 million. The world's numbers are expected to increase by 44 percent by 2000—to 5.6 - 6.8 billions, meaning a further reduction in uninhabited space that can be used for food production. Industrial and urban areas will spread. The pressures already existing to exploit natural resources will multiply. If the national parks wish to preserve their natural resources for the long term, they will have to assist directly in global survival to survive the competition.

Threats to National Parks

The environmental and habitat changes already are being felt in the parks. In the 1980 State of the Parks Report to Congress, 310 National Parks reported 4,345 threats. Categorically these were aesthetic degradation (land development, timber and other extractions, roads, etc.) air pollution including acid rain, physical removal of resources including oil and mineral extractions, erosion, hunting, exotic encroachment and decreased water quality and quantity. This report exposes the vulnerability of the parks and their resources to degradation (See *Trends* Vol. 19, No. 1, article by Roland H. Wauer.) Biological resources accounted for 32 percent of all threatened resources; physical resources 24 percent; aesthetic resources 20 percent; cultural resources 16 percent; and park operations 8 percent. At least 75 percent of the threats identified still need research to document them.

A little over 11 percent of all the threats or problems reported occurred in the 15 parks designated as Biosphere Reserves. This is especially disturbing because these parks have been singled out to represent the most undisturbed natural areas for the major North American biomes (habitat types). Recognizing the existence of threats to the parks, even before the survey, the National Park Service chose to participate in an international cooperative project which addresses the geographically redundant problems of man and the biological resources. This is

the International Program of Man and the Biosphere (MAB).

The MAB program originated in the United Nations Educational, Scientific and Cultural Organization (UNESCO). It focuses its attention upon bridging the leap from scientific research to technological applications. MAB examines the relationship between man (society) and the biosphere (the global environment). This program is one of the most successful attempts to mobilize politicians and scientists internationally to deal with global problems of the environment. It owes part of its success to its philosophical approach—that of man as an integral part of the biosphere in which he suffers or gains from the effects of change, just as other resources do.

MAB project areas include; tropical forests, grazing lands, temperate forests, mountains, pesticides, fertilizers, engineering works, pollution, acid precipitation, environmental quality, urban ecosystems, and demographic change. Mab Project 8, "Conservation of natural areas and the genetic material they contain," focuses on the establishment of an international network of Biosphere Reserves for the study of biological diversity, environmental change and man.

In Project 8, the MAB program functionally combines natural areas such as parks with experimental areas, i.e., wildlife refuges or national forests. These paired areas are called "biosphere reserves." Each biosphere reserve is representative of a biome. It is hoped that in time all biomes will be represented. There presently exist 193 UNESCO-designated biosphere reserves in 50 countries; 36 biosphere reserves have been designated in the United States, 15 of which are national parks. It is through the doorway provided by MAB Project 8, that the National Park Service has entered a new era in habitat and natural resource management.

A recent report by Risser and Cornelison (published by Oklahoma Biological Survey, 1979) describes the existing biosphere reserves and surveys the published literature on the ecological and environmental relationships of biosphere reserves. The value of such a survey is in delineating the directions cooperative projects can take between reserves. Similarities in climate, vegetation, and animal life are conducive to establishing experiments to test the effects of different management practices. Thus, Risser and Cornelison compared the biological, physical, climatological, and management characteristics of U.S. Biosphere Reserves.

For example, Fraser Experimental Forest, Olympic National Park, Rocky Mountain National Park, Sequoia and Kings Canyon National Parks and Grand Canyon National Park share alpine meadows. Fraser, Rocky Mountain, Yellowstone, Glacier, and Denali share similar precipitation characteristics. Fraser, Yellowstone, Glacier, Rocky Mountain and Denali share similar temperature regimes. In spite of this overlap in characteristics, all of these differ substantially in soil characteristics. Nevertheless, Fraser Experimental Forest and Rocky Mountain National Park undoubtedly make an excellent pair (experimental area + natural area) for studying the biosphere. Similar attempts are being made to look for like pairs of biosphere reserves for comparison across continents. Programs such as MAB not only increase international cooperation but have the potential to benefit any country which has similar climate and houses similar biota to those characteristic of biosphere reserves.

Origins of MAB Program

As far back as 1948 Sir Julian Huxley supported the gathering of an international conference of UNESCO and France to found the International Union for Conservation of Nature and Natural Resources (IUCN). And in 1961, Dr. Pierre Auger, a French physicist and former head of UNESCO's science department, conducted a survey of trends in inquiry in the natural sciences. On the basis of his survey, he recommended that UNESCO focus on environmental programs.

This focus was encouraged by Victor Kovda, a Soviet soil scientist who succeeded Auger. In the early 1960's, their efforts materialized with the establishment of the International Biological Programme (IBP), spurred on by Dr. Stanley A. Cain, an American plant ecologist. Though the IBP program was short-lived, it gave way to a broader proposal that would establish a network of natural and experimental ecological reserves.

Finally, the UNESCO general conference in November, 1970, established the program on Man and the Biosphere. The purpose

The *ankh,* the Egyptian sign for life, is the symbol incorporated into the MAB symbol.

MAB

U.S. MAN AND THE BIOSPHERE PROGRAM

of this program was to study the structure and functioning of the biosphere and its ecological regions. It was to examine systematic changes brought about by man in the biosphere, study the overall effects of these changes upon the human species itself, and provide education and information on these subjects.

The International Coordinating Council for MAB soon was established. Thirty of 100+ participating nations now form the council which directs the international operations of MAB through its secretariat. In 1972, responding to the invitation of the Director General of UNESCO, the U.S. Department of State established a National Committee for MAB. This U.S. National Committee advises the U.S. Government on UNESCO's programs and serves as the link between the U.S. and UNESCO. The U.S. MAB committee chairman represents the United States in the International Coordinating Council of MAB.

Each MAB project coordinated by the U.S. National Committee is administered by a directorate of selected experts. The chairman of each directorate represents his or her scientific project on the National Committee. Presently, there are 14 directorates in which the participating scientists and other experts formulate the scope and focus of each project including training, research, and research implementation activities within the project. Today 25 agencies, at least 50 universities, and about 200 scientists and administrators participate in the program.

Biological Diversity

Because MAB and its participating organizations focus on the topic of biological diversity, it is imperative that managers in these organizations understand the meaning of biological diversity.

As was made clear in the *Natural Resources Management* issue of *Trends(Vol. 19, No.1)* in the articles by Wauer, Weisbrod, and Schonewald, legislating boundaries of the national parks is not sufficient to maintain the health and diversity of park ecosystems. This is because the maintenance of diversity (the number and quality of both plant and animal species) depends upon the availability of *entire,* self-sustained, ecosystems. It is only in the case of intact ecosystems that a "fence-it-and-leave-it-alone" policy will work.

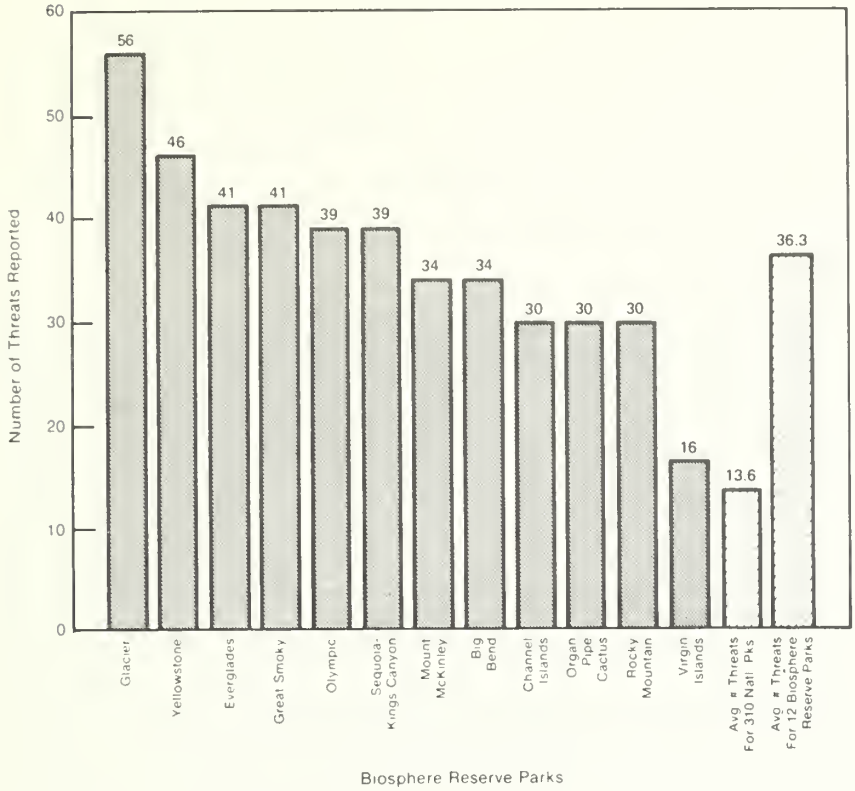
The reality of our situation is such that few parks enclose what can be considered large enough *portions* of ecosystems to be completely self-sustaining. Instead, for some species they are cages, which restrict the natural flow of individuals, food, and other resources necessary for long term survival. For species such as these, encroachment of threats into the parks or the species movement across park boundaries in a search for additional resources results in death, while remaining within the park confines means competition for limited resources. The primary focus of MAB in the national parks is to maintain ecosystems, but it is increasingly being recognized that "management medicine" is needed for such populations of very large or highly specialized animals (wolves, grizzlies, bighorn sheep, etc.). Endangered species (plant or animal), whether they are dying out because of limited resources or being plucked out of existence, all need special management care in addition to a protection of their respective ecosystems.

This year MAB Project 8 is engaging in a training and information transfer venture to educate resources managers about the complexities of managing and preserving threatened or "difficult" populations. The tools of small population currently being used by zoological parks and botanical gardens and which, for other ends, have been used by agriculture and the livestock industry, now are in the realm of park management. MAB decided to provide state-of-the-art techniques to those most in need of them.

Symposium and Workshops

The venture I have just described is the August 9-13, 1982 Symposium and Workshop in Washington, D.C. on the Application of Genetics to the Management of Wild Plant and Animal Populations. This training and technology transfer is of the genetics and ecology needed to develop programs for managing isolated and small populations. It also touches upon the techniques of restoration of populations that have been extirpated. The Symposium and Workshop, partly NPS-sponsored, covered five basic topics central to the management of populations of plants or

Number of Threats Reported for the Individual NPS International Biosphere Reserves as Compared with Average Number of Threats Reported for All National Parks



Taken from "State of the Parks - 1980: A Report to the Congress" (May 1980) National Park Service, U.S. Dept. of the Interior

animals potentially or already in trouble.

The first objective of this program compared the consequences of natural isolation to that resulting from manipulation of habitat by man. This included examination of the various genetic effects of natural or human influences causing isolation, and the subsequent pathological symptoms, underlying causes of population decline, and divergence from normal population characteristics.

The second program objective compared the processes by which population declines lead to extinction. It concentrates on the immediate cause of declines, the underlying factors that may precipitate the decline, and the means of diagnosing the decline.

As its third objective, the program examined naturally occurring colonizations and restoration efforts establishing new populations. It also explored colonization success in light of a species' behavior, reproductive traits, and ecological relationships, and covered requirements on the structure and composition of the initial founding group.

The fourth program objective was to examine the beneficial and deleterious effects of connecting once separated populations. These new connections may result from natural causes, from human transport of organisms, or from habitat alteration. It is important to explore here how merging of populations can be used advantageously to assist genetically depleted and declining populations, by creating movement of individuals between them. And conversely, it is crucial to understand the pitfalls that can result from the mixing of animals or plants from different populations.

The final objective was to discuss a subject many ecologists and managers have put aside as old-hat but which is very critical to the protection of natural resources. The use of taxonomy and systematics is vital in managing species. To ignore or overlook these tools can lead to inadvertent damage to populations or to the reversal of hundreds or thousands of years of evolution and adaptation to local habitats. Thus, the program addressed the effects of connecting once separated populations. It explored the uses and techniques of the long established sciences of taxonomy and systematics for use in conservation and preservation.

Conclusion

The National Park Service, guardian of so much of the United States' natural resources, is also becoming the source of large scale medicinal care for threatened populations, which are totally dependent upon resources management for survival. (Some very complex and far reaching decisions and implications lie in the hands of individuals sometimes unequipped to deal with them.) It is through continued involvement with cooperative programs, with international projects such as MAB, organizations such as UNESCO or IUCN and with the scientific community here and abroad, that the newest and most productive techniques can be applied to this once simple objective: "to protect and preserve natural resources for the enjoyment of future generations."

Christine Schonewald-Cox, Ph.D., is a Biologist with the National Park Service's Division of Natural Science.

Parks, Science, and Volunteers — A Winning Mix

by Mark C. Jorgensen

Out on the inland desert of Southern California (known as "the Colorado Desert") at Anza-Borrego Desert State Park is unfolding a success story with three important ingredients—a band of dedicated park volunteers, a strong scientific research component, and a park management that welcomes and works well with this mix.

Park Volunteers

In the face of the 1970s governmental belt tightening, the Anza-Borrego Desert Natural History Association (ABDNHA) flexed its volunteer muscle and raised more than $600,000 to help construct and equip one of the finest park visitor centers in the nation. To operate the center and bring a wealth of natural history and culture appreciation to the public, ABDNHA in 1979 formed the Park Volunteers, to supplement the park staff. As a result, the 1.3 million visitors to Anza-Borrego in 1981 were superbly served by 80 volunteers!

The men and women who make up the body of this volunteer corps are not the casual "drop in/drop out" variety. All of them complete an intensive 40-hour training course prior to their service. They delve into paleontology, archeology, desert plants and their unique adaptations, wildlife, geology, history, park rules, map reading, and camping opportunities.

Research and Interpretation

The blending of scientific research and park interpretation has an exciting effect on the volunteers themselves, and this excitement is transmitted to the visitors.

Anza-Borrego Desert State Park

Pictograph made by a researcher and enjoyed by visitors.

Research in this 600,000 acre desert park has been conducted in many disciplines. Park volunteers have been attracted into paleontology, both field and laboratory research work. Guided by George Miller, curator of paleontology at Imperial Valley College, the classes have made discoveries of worldwide importance. Recently uncovered was a giant zebra known only in the Anza-Borrego Desert and the only modern horse known to the New World. Mammoths, tapirs, dire wolves, camels, and turtles are subjects of the volunteers' studies. Interpretation of this research is exciting and takes several forms.

Fossil exhibits in the Anza-Borrego Visitor Center include the jaw of an Imperial mammoth, panels explaining the climatic changes that have occurred over the last 10 million years, and an explanation of the methods of fossil preparation. The paleontology laboratory also is open to visitors who can watch the ongoing preparation, research, and storage of fossils.

Anza - Borrego Desert State Park

Park Aid Sylvia Wegner talking on bighorn sheep to an international visitor.

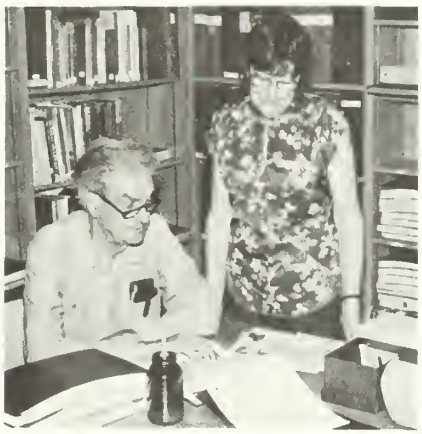
Campfire programs and demonstrations take the visitor millions of years back to the Pleistocene times. Research was indispensable in providing the background material for these programs.

Archeology is presented in lay terms by volunteer Robert S. Begole, who for 10 years has conducted field research into paleo-man sites throughout the Borrego Desert. His publications, photo journals, and artifacts assist interpreters in making these ancient cultures real for the park visitor. Begole's donation of a research facility has made possible the further discovery and storage of items for the park's valuable artifact collection.

Rock art sites have been studied in-depth by Ranger Manfred Knaak and Daniel McCarthy. Knaak is presently compiling photos, site records, and a documentary book which will be published in the near future. His course on the archeology of desert Indians is given to park volunteers in their initial training class.

This archeological research has been interpreted and made part of exhibits depicting paleo-man, rock art, food preparation, and the art of pottery making.

Archives of the park's history are compiled and catalogued by volunteers Joe and Catherine Stone. Joe was for many years a staff writer for the *San Diego Union*, and since retirement he has donated his talents to the park. Thousands of newspaper, magazine, and brochure articles have been brought together and indexed by the Stones. This information trove now is used for research by park staff, visiting researchers, and the general public.



Anza - Borrego Desert State Park

Joe and Catherine Stone, workin', on park archives.

Desert bighorn sheep have been the subject of studies in Anza-Borrego for many years. Research has provided data to park managers on the population, range, food habits, and management needs of this rare animal. Visitors reap the benefits of such work in campfire programs, talks to outside groups, bighorn observation tours, and in tours of the Visitor Center lab—where a bighorn skull collection provides "hands-on" experiences.

Further studies in the areas of plant communities, ranges of rare and endangered plants, and recovery of habitat after fire have provided a wealth of data to be used in resource management and interpretation.

Research Library

A research library funded by ABDNHA is an integral part of the Visitor Center complex. Hundreds of books are available to the public and many hundreds more are scheduled for future acquisition. The goal set by the volunteer group is to make this library the most complete collection of references on the Colorado Desert in existence.

The Anza-Borrego Natural History Association promotes and publishes its own books on the park as well. A guidebook, a large format color publication, a children's coloring book, and natural history checklists make up the association's collection of interpretive publications.

The management of Anza-Borrego Desert State Park in cooperation with ABDNHA provides tremendous interpretive services to thousands of visitors each year in the Visitor Center. Through the unceasing energies of 80 volunteers, the intricate and delicate desert world is brought into the lives of countless people, in particularly meaningful ways.

Scientific research has provided a body of information which the volunteers and park staff have been able to tailor to suit the interpretive needs of the thirsty souls who come in droves. The result has been a phenomenal gain in appreciation for the desert realm that is Anza-Borrego Desert State Park, and a deeper public understanding of the paleontology, botany, history, and archeology of early life in this rich and fragile area that is at once the public's pleasure and its trust.

Mark C. Jorgensen is a park naturalist at the Anza-Borrego Desert State Park in California.

An Answer to "When Are You Going to Quit"?

by Rolf O. Peterson

Rolf O. Peterson

Wolf predation has been eliminated in almost all of the conterminous 48 states.

Long-term research—in many cases a practical necessity but invariably a difficult order to fill. Research scientists may be quick to point out that definitive answers to ecological problems often require more than a quick field season or two; this is certainly true for long-lived wildlife species subjected to the vagaries of weather, habitat change, parasites, and predators. As land use intensifies and research funding dries up, we face a regression in ecological inquiry at the very time we need it most.

National parks in the United States, and equivalent preserves around the world, are rapidly becoming primary sites for ecological research, especially for studies that require natural assemblages of species and habitats. Even among national parks, rarely do we find ecological conditions that we could call "pristine," completely unaffected by man's heavy hand. Wolf predation, for example, the powerful agent of natural selection for most ungulates in the Northern Hemisphere, has been eliminated in almost all of the conterminous 48 states, and in U.S. national parks outside Alaska wolves hang on only at Isle Royale, Voyageurs, and perhaps a handful in Glacier.

Durward Allen, who has long held the view that a premier value of national parks was their value to science as remnants of the natural order, initiated a "10-year study" of wolves and moose at Isle Royale National Park in 1958, and fortunately didn't quit when the decade was up. The efforts of his students and mine (I succeeded Durward as project director in 1975) have borne much fruit, but it seems an obvious conclusion that, even after 23 years of work, each additional year produces proportionately more valuable data. The dollars invested in this research by the National Park Service, National Science Foundation, and almost every major conservation organization in the United States have, I believe, been well spent, as Isle Royale stands almost alone in providing major insight into large mammal predator-prey interaction in the Northern Hemisphere. Such an understanding could not have been reached after the usual 3-to-4 year population study. Even after a decade of study, we did not anticipate the general scheme of what would follow.

Isle Royale Wolf Population

During the 1960s, the Isle Royale wolf population exhibited remarkable stability, at about two dozen animals (Figure 1). The moose population, after building up within a large burn dating from 1936, was high and probably increased during this period. Wolf predation was highly selective for calf moose and old individuals exhibiting a high incidence of skeletal pathology. Some sort of stable, natural "balance" seemed to have been struck. To many this seemed to indicate that wolves helped maintain stable, productive prey populations. Wolf research helped stir public in-

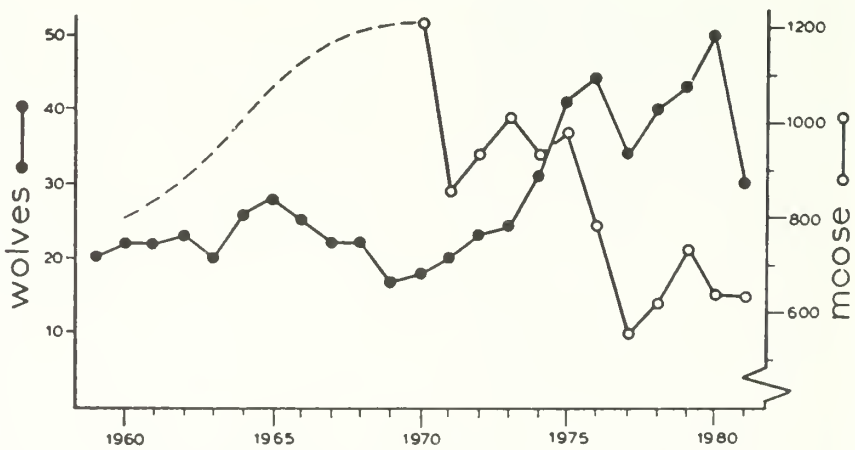
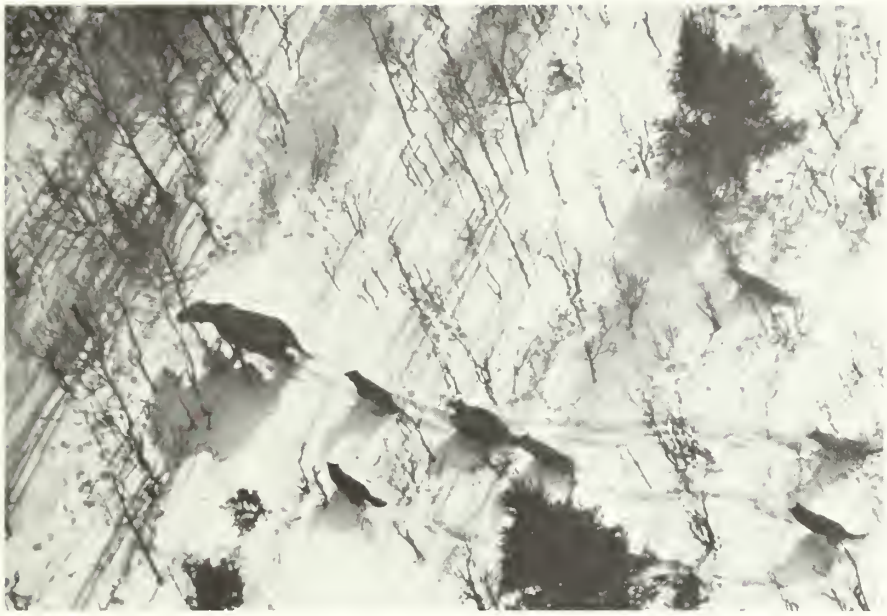


Figure 1. *Population fluctuations of wolves and moose at Isle Royale National Park over the past 23 years.*



Rolf O. Peterson

Wolves stalk their ungulate prey.

terest in wolves and contributed to a reduction in wolf control efforts across North America. During the 1960s and early 1970s wolves in North America generally increased, recolonizing some of their former range, just as humans bent on resource extraction moved into much of the remaining range.

The 1970s saw a continuation of Isle Royale wolf research plus several additional studies involving wolves and virtually every principal prey species utilized in North America. A broadened scientific understanding of wolf-prey interaction and population regulation continues to evolve.

The past decade of study at Isle Royale has been a genuine eye-opener, as the apparent stability of wolf and moose populations was replaced by drastic fluctuations. In 1970 the wolf population was relatively low and both moose and beaver (alternate prey for wolves in summer) were at the highest levels observed in two decades. Moose density remained high in spite of a gradual reduction since the 1950s in forage that had been rejuvenated by the 1936 fire. A string of severe winters in the early 1970s emphasized the marginal food base for the moose population, wolf predation increased by an order of magnitude, especially on calves floundering in deep snow, and wolves supplemented their limited diet of moose calves in summer with abundant beaver.

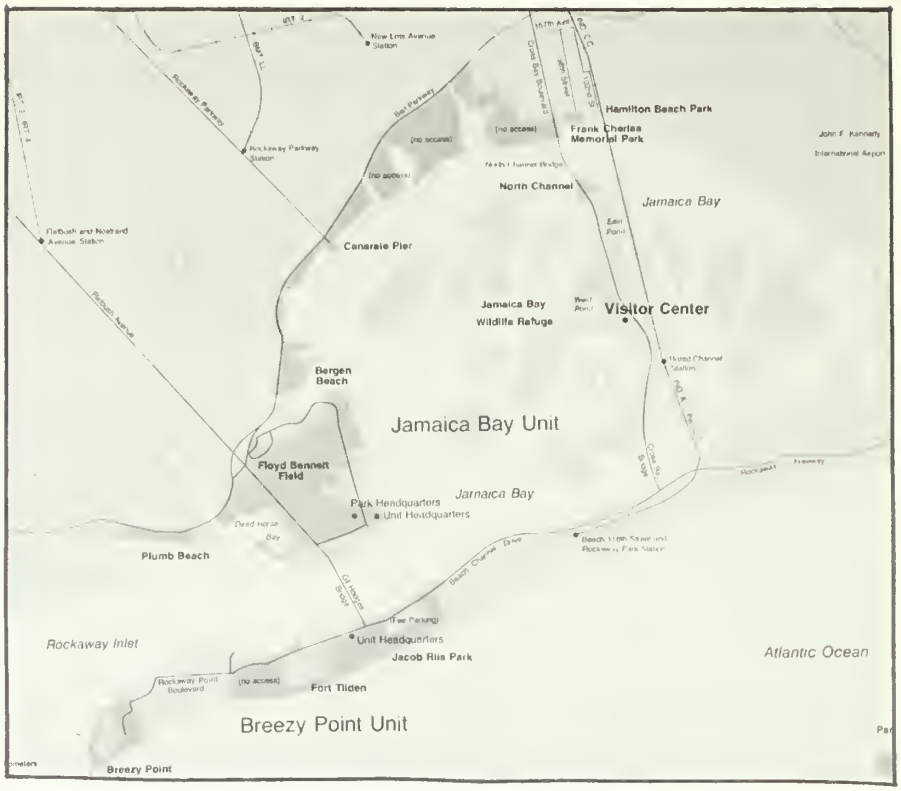
For nine of the next ten years, the wolf population increased; both prey species declined, moose by 50% and beaver by about 75%. The wolf population reached a peak level of 50 about 10 years after peak prey populations, indicating an exceptionally long lag period for this predator-prey system. Currently the moose population and probably beaver as well have stabilized, and the wolf population is dropping rapidly as a result of high mortality and low reproduction.

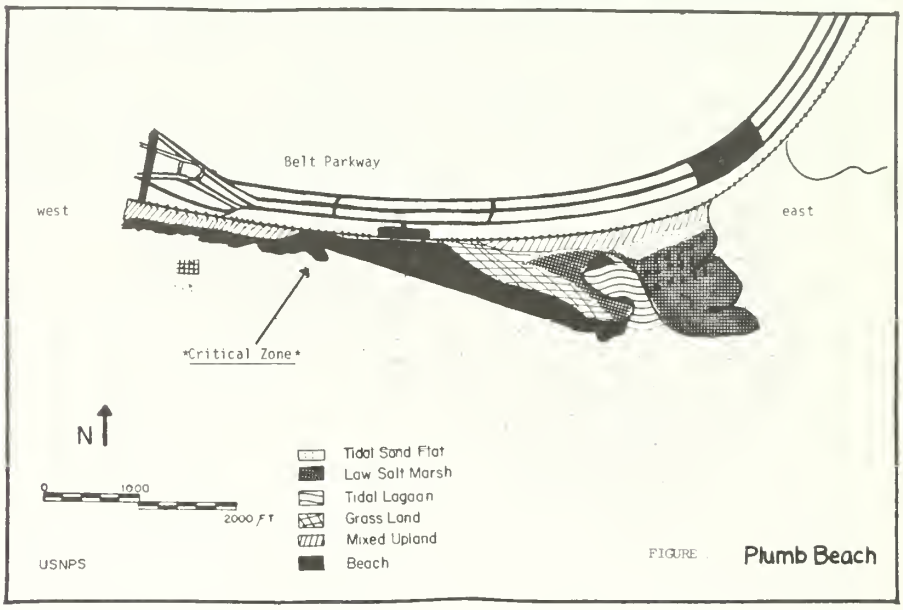
Peak prey populations in the 1960s seem to have been promoted by renewed habitat that followed fire three decades earlier. Forty to 50 years after the fire, are we now heading for a new "stable" equilibrium in moose and wolves? Or will these populations fluctuate in some sort of cyclical fashion, albeit with an exceptionally long period? Current wolf research on Isle Royale and elsewhere suggests that wolf predation may be an important regulatory influence on prey density in some cases. Where human hunting intensity is high, it is at least evident that wolves and human hunters may at times compete for the same prey. It is likewise evident that humans will largely assume the role of "manager" of prey and predator alike, and natural selection will be supplanted by an imperfect knowledge that stands to advance only to the degree that we maintain a few intact pieces of the natural puzzle.

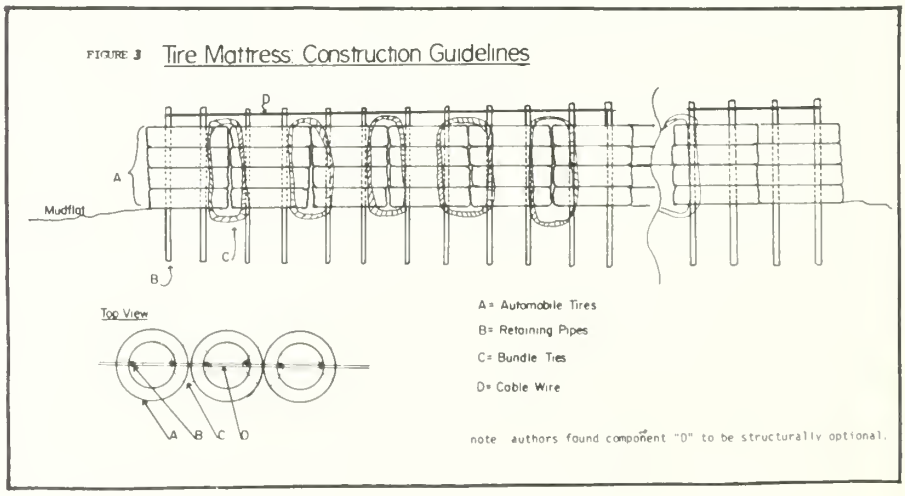
This article first appeared in the Autumn 1981 issue of Forum, a publication of the George Wright Society.

Shoreline Stabilization Through Marsh Restoration

by Bonnie Lou Gay and John T. Tanacredi







The most encompassing problem facing Gateway National Recreation Area (NY-NJ) in the foreseeable future is the impact of coastal erosion on natural, geomorphological and cultural resources. With a projected 18 million visitors per year, of which a majority come to use bathing beach areas, erosion is a significant threat through loss or damage of shoreline, cultural resources, structures and transportation corridors. Erosion causes loss of critical habitat that has been identified in Gateway's Resource Management Plan as drastically reducing species diversity while significantly impacting upon those areas designated for protection within the park boundaries.

The major problem becomes how to stabilize these areas. Several miles of beach surrounding Jamaica Bay (Figure 1), are subject to sand erosion by wave action, tides and storms which keep changing the profile of these beaches, sometimes overnight.

Several engineered methods have been attempted to correct the erosion threat to recreation areas with little success. Shoreline areas as they stand represent the passage of considered periods of time coupled with the dynamics of shoreline geomorphological process such as wind driven waves and currents of significant force.

These factors have considerably altered the contour of the shorelines associated with Gateway NRA. In most cases, National Park Service (NPS) policy has been to allow "nature to take its course." Yet in cases where the NPS has inherited a history of "engineered solutions"

to the coastal erosion problem, this approach (allowing nature to take its course) may be totally incompatible with existing and projected visitor use patterns. Existing engineering techniques to control erosion involve the building of structures such as seawalls, bulkheads and revetment. These structures have such critical limitations as their high cost for labor and materials. New techniques involving physical intervention between sea and shore need to be explored.

Researchers are experimenting with ways of working "with nature" to protect the natural setting of shoreline areas. One such method, which has received considerable attention, is vegetative propagation of marshgrass; *Spartina alterniflora*. The principle is simple. Once a marsh is established the marshgrass root system will collect and consolidate sand particles and thus provide a natural barrier or "buffer zone" to the destructive forces of waves. Along with providing a natural breakwater, marshgrass filters out some water pollutants and provides habitat for developing estuarine/marine species.

The Plumb Beach Experiment

The Plumb Beach area, once an island, has undergone dramatic configuration change. The once low-lying hassocks of marsh gave way to one of Brooklyn's major highways—the Belt Parkway. Landfill and construction smothered the productive shellfish beds lining the periphery of Jamaica Bay. The east end of Plumb Beach (Figure 2) still harbors an extensive marsh/lagoon system. The west end is the site of critical erosion. Much of the shoreline area, public access roads and beaches were lost in the October 1980 storm.

Prior to the 1980 storm, erosion prevention measures included 1) placing sandbags along the shoreline, and 2) placing timber pilings parallel to the shoreline. Neither method was effective. A pilot marsh transplanting project, conducted in 1979, met with limited success due to early impacts of Hurricane David, which killed surviving culms of *Spartina alterniflora* before their first winter season.

During the 1980 winter season, careful planning was considered for shoreline stabilization through marsh restoration. Natural marsh areas existed to the extreme west of the critical zone and to the far eastern end of Plumb Beach. Even throughout storms and hurricanes these marsh areas continued to stand as buffers for the shoreline. The parallel dune system and adjacent upland areas provided still another protective zone to this ecosystem as a whole. The "critical erosion area" of Plumb Beach had lost its upland-dune buffer zone and now had only a major highway system, within 50 feet of the high water mark. The only area left between water and highway was the tidal flat itself.

Since Plumb Beach lies within the limits of Jamaica Bay and for the most part experiences relatively shallow water waves, the dynamics and forces of its littoral environment were ideal for a marsh restoration program. Plumb Beach lies close to both lower New York Bay and the Atlantic Ocean (buffered by the Breezy Point peninsula). This is an important factor when one considers relative water patterns during extreme weather conditions. Other factors contributing to the erosion of Plumb Beach include 1) the presence of a dredged navigational channel (used to gain entry to Sheepshead Bay), and 2) the presence of a rip-rap wall that may have played a role in the depleting sediment supply to the Plumb Beach shoreline.

During low tide, current ripple marks are evident throughout the tidal flats, and as in most eroding areas an angled wave approach to the shoreline exists. Still, there was marsh development to the east and west of this critical zone. The question was how to get marsh culms to exist long enough to comprise a viable system in Plumb Beach critical zone...how could the park successfully slow down wave action to establish a marsh with relatively little cost and alteration to the natural environment?

At about this time the "Coastal Engineering Research Center" (CERC) (part of the U.S. Army Corps of Engineers) received congressional funds for the development of low cost erosion control structures. One such project was the "FTB," or Floating Tire Breakwater. Its function is to decrease the amplitude of incoming waves to a particular shoreline. Researchers tested wave energy reduction with FTB's in harbor areas and found them successful.

One variation of the FTB is the "tire mattress." It's major function is to absorb and reflect energy from incoming waves. Different from the FTB the tire mattress rests on something, in this case, on the tidal flats. Cor-

rectly positioned on the tidal flats, a tire mattress could serve to reduce wave energy within a marshgrass planting site.

Phase I: Tire Mattress Construction

With approvals from the Army Corps of Engineers and the New York State Department of Environmental Conservation, construction of a tire mattress by Gateway NRA at Plumb Beach began in the Spring of 1981 and ended in May of that year. The project took longer than expected, as we did not estimate alternating work weeks due to tide conditions. The tire mattress at Plumb Beach is 440 feet long and lies parallel to the shoreline, about 260 feet into the inter-tidal zone on a gently sloping mudflat. The bundles are held in position by pipes and are attached to one another by plastic encased steel cable (see Figure 3).

Perpendicular to the shoreline lie six shorter segments of tire bundles called "finger projections." Their function is to trap moving sand. Used together the tire mattress and finger projections slow down wave action and build up sand.

Phase II: Marsh Development

The primary goal of this project is to establish a marsh system. With the completion of the tire mattress and finger projections the site was ready for grass. Because of the advanced stage of the growing season (mid August), a pilot planting was substituted for full scale planting. Transplants of marshgrass within the project site tested a range of parameters: commercial stock vs. natural culms, different locations within the critical zone, different sediment types (i.e., presence of clay or peat deposits), and first year vs. second year growth. The comparisons proved informative and the preliminary results set the standards for later marsh restoration work at Plumb Beach.

National Park Service

Aerial view of the tire mattress and finger projections during a flooding tide at Plumb Beach, NY.

Many researchers have worked on guidelines for planting marshgrass; Dr. Paul Knutson, Dr. E.W. Garbisch, Dr. W.W. Woodhouse are only a few. They continue to document information on marsh development and restoration as an aid to those who wish to propagate this valuable species of grass. Dr. Garbisch, president of the nonprofit organization, Environmental Concerns, located in St. Michaels, Maryland, grows and sells several marsh/dune grass species for use in this manner. Commercial stock has proven to be less labor intensive to transplant and has a higher survival rate than transplanted "natural" (existing) culms.

Spartina alterniflora plays a significant role in the estuarine environment. It provides an intricate, multifold link to the marine ecosystem. *Spartina alterniflora*, a dominant inter-tidal species is found growing along coastal fringes of the eastern United States. Patches of marshgrass known as "stands" supply our coastal waters with a nutrient source that surpasses in primary productivity any other agricultural system.

To marine and estuarine species *Spartina alterniflora* is most valuable in its decomposed form. Marshgrass dies back after a spring-summer growing season

and takes another form known as "detritus." This microscopic plant material is carted out by the tide to the surrounding bay waters and is utilized by developing estuarine organisms. It is a key component of this marine food chain. Without the continuous contribution of this nutrient material to our coastal waters, there would be a marked decrease in abundance of marine life and, in turn, reduced productivity.

Marshlands, often referred to as wetlands, are universally known as the "ocean nursery." It has been estimated that 70 percent of all marine life depends on marshes during some point of its existence, whether for food or as a site for breeding. Birds and small mammals also make use of wetlands. Other beneficial conditions that may result from this marsh development/erosion protection project include creation of a natural breakwater to mitigate the forces of storm conditions and waves, and an increased production in natural peat soils (which will absorb run-off water during rain and storm).

The existence of marsh should increase the ability of the area to absorb sewage effluent, which, with the addition of suitable grasses to "take it up," becomes a nutrient instead of a pollutant. In the marsh, excess nutrients would produce increased growth for marshgrass, providing an increased supply of food energy to the food chain. Disposal of wastes high in nutrients (such as sewage effluent) would be less disruptive to the Jamaica Bay ecosystem if absorbed by the saltmarsh rather than being emptied into open water.

National Park Service

1980 storm destruction at Plumb Beach, NY.

Conclusion

Reduction of shore erosion presents many problems, more of them relating to the high cost of design and construction of protection structures. This calls for careful correlation of protective measures with a specific site's physical conditions and coastal geomorphological processes. Areas such as Plumb Beach contain within themselves the potential solution to their erosion problems through marsh development. With the temporary addition of wave damping devices such as the tire mattress, project cost factors are considerably reduced.

The feasibility of working with tires is important both economically and practically. Tires used in such stabilization structures are capable of deforming up to 30 percent without permanent change in shape. Because of their relative inertness, tires experience a relatively slow breakdown of structure, maintaining strength and flexibility for long periods of time. Best of all, tires are inexpensive and plentiful. In addition, their use in back stabilization helps solve a waste tire problem.

The benefits of a marsh system to the environment and the surrounding waters of Jamaica Bay include provision of habitat for many species, a buffer zone for wave action and flood plain areas, and a natural sink for a variety of pollutants. Marsh creation will increase bio-mass and productivity to the bay and surrounding waterways.

This first of what is planned to be several marsh restoration shoreline stabilization projects at Gateway NRA proposes to reestablish a valuable yet dwindling urban natural resource: namely our coastal wetland environments.

Bonnie Lou Gay is the Resources Management Technician for the Jamaica Bay District and John T. Tanacredi is a Natural Resources Management Specialist with Gateway National Recreation Area (NY-NJ).

The Peregrine Falcon Story

by Jean Matthews

If the endangered peregrine falcon actually stages a population comeback in the Pacific Northwest, it will at least partially be due to the cooperative scientific expertise of three federal government agencies, one state agency, and a private group based in academe.

Keeping in mind that all life on Earth is a continuing story, this particular peregrine falcon saga currently has overtones of "happy ending." The opening scene is Crater Lake National Park in Oregon and the scenario begins with the discovery in 1979 of a currently active falcon nest. Charles Bacon of the U.S. Geological Survey discovered the site as he was doing research on the Crater Lake caldera, where peregrines were known to be resident breeders in years gone by.

Nest Watch

The National Park Service set up a nest watch, under the direction of Mark Forbes, resource management specialist at Crater Lake, with the full backing of Park Supt. James Rouse—determined that Crater Lake National Park would continue as an arena for this spectacular species.

The nest watch recorded the successful fledging of two peregrine young that year, but after the nest was vacated an NPS recovery team found one unhatched egg. Shell samples were sent to the U.S. Fish and Wildlife Service (USFWS) research center at Patuxent, Maryland, where analysis showed that DDE (a derivative of DDT) was present in quantities sufficient to cause shell-thinning. (Shell-thinning already had been established scientifically as a significant factor in the decreasing numbers of peregrine falcons.)

In 1980, the nest watch set up by the Park Service and USFWS found that none of the three eggs laid by the returning pair had hatched. Analysis this time showed eggshell-thinning, dehydration of the embryos, and high levels of DDE in both the shells and the embryos.

Luther C. Goldman, USF&WS

There is new hope for the endangered peregrine falcon population.

It was at this point that the state and private agencies entered the picture. Mark Forbes narrates:

"What we knew then was that Crater Lake National Park had the only known pair of nesting peregrine falcons in the entire state. So we called in the Oregon Department of Fish and Wildlife, the USFWS, and the Predatory Bird Research Group at the University of California, Santa Cruz, for technical advice and assistance. With their help, we patterned a plan of action following the guidelines of the Pacific Coast Recovery Plan for Peregrine Falcons, but tailored to the particular conditions we were facing."

(The Recovery Plan is part of the procedural strategy of the USFWS for all endangered species on the Federal list.)

The Recovery Plan

"We knew the eggs were failing to hatch," Forbes said, "and it was also known that after a certain number of years of failure the birds become less likely even to attempt reproduction. We had lost one egg in 1979, all three eggs in 1980. So 1981 was a crucial year in terms of this particular pair."

The decision wasn't easy. Should the approach be to take the 1981 clutch of eggs from the nest and incubate them at the lab in Santa Cruz—trusting to chance whether or not the pair would attempt a second clutch? Or should the effort be made to "foster," which means to take the eggs and replace them with newly hatched young from the Santa Cruz laboratory incubator? (The young would come from eggs laid at the Predatory Bird Group Facility at UCSC or from eggs removed from other nests where successful hatching was similarly in question. This technique of placing foster young with parents whose eggs have failed is called "fostering.")

The plan with the most pluses going for it (as well as the least disturbance involved) was the fostering plan. If all went well, the removed eggs would hatch in the California laboratory, the replacement chicks would grow to adulthood, and the Crater Lake pair would continue to nest and lay eggs in future years.

Fostering Plan

The decision for fostering was made by Park Supt. Jim Rouse,

in conjunction with Park Service scientists, with Brian Walton, head of the Predatory Bird Research Group at Santa Cruz, and with Charles Bruce, non-game wildlife biologist with the Oregon Department of Fish and Wildlife and the USFWS.

Preparations were painstaking. Information was needed about when the birds came to the nest, especially when they began laying their eggs, and specifically what their habits were—right down to the minute. All this data was critical if the transfer stood a chance of being made within the time frame when the removed eggs, the transplanted young, and the unsuspecting parent birds were at their maximum moment for success.

So the Park Service hired an individual to ski out to the nest site and begin detailed chartings of the birds' activities. Through field glass observation, the egg-laying dates were established while the snow still lay heavy on the ground in early spring of 1981.

The 10 days following egg-laying become the "critical time" for manipulation. Forbes explained it this way:

"At about 10 or 11 days into the 3-weeks incubation period, the nesting pair 'commit' themselves to the eggs. Somewhere around that point, the birds develop the expectation that the eggs are going to hatch. Only after that length of time would the pair be likely to accept young birds instead of eggs in the nest. Also, without some wild incubation, captive-incubated eggs are less likely to hatch. So we had to wait."

The waiting period was by no means inactive for recovery team members. Word of the laying of the first egg set in motion a precision exercise. Endangered species manipulation is covered by stringent regulations. Proper permits had to be issued by the authorized agencies and finalization of all the paper work was going on at the same time that the mechanics of the exchange were being readied.

Eventually the action involved 14 people, including two pilots, plus one small private plane, one helicopter, snowmobiles, motor cycles, skis and mountaineering gear and expertise. At the crucial moment, a plane flew from Santa Cruz, California to Chiloquin, Oregon (just outside Crater Lake National Park) with two female falcon chicks two weeks old, accompanied by experienced personnel from the Santa Cruz facility.

Waiting at Chiloquin was the Oregon Fish and Wildlife Department's helicopter, with one of their personnel. One Santa Cruz person and the two chicks were helicoptered into the park to a pad one-half mile from the nest site.

Meanwhile, "to get all our people to the site to effect the transfer," Forbes said, "we had to drive to the end of the plowed road, snowmobile through the snow blockage that could not be removed, then motor cycle from the other side of the snow blockage on cycles that had been snowmobiled in some days before, and get our climbers, observers, and gear in place on time to meet the chicks." (Winter snows are deep at Crater Lake and the Rim Drive is not cleared until later in the year.)

Once the helicopter landed, it was the biologists from Santa Cruz that carried the action. As the chicks were walked to the site, the biologists (who were also experienced climbers) flushed the nesting pair, leaving the falcon eggs exposed on the bare cliff ledge. The falcon young were handed to a climber who descended to the ledge, lifted the three eggs into a specially prepared receptacle, placed the chicks on the ledge, and "jumarred" out (climbed back up the rock wall) carrying the precious eggs.

One hour and two minutes elapsed from the time the falcons were flushed from the nest site until they were back, brooding the two young chicks.

From here on, the sequence of events was reversed. The eggs were handed to the personnel who had brought the chicks, placed in a specially prepared warmed container, taken to the helicopter, lifted out to the Chiloquin landing strip, flown to California, and put into intensive care.

Two of the eggs were found to be viable (the embryos still alive), while one appeared to have died shortly after laying. Of the two still alive, both were dehydrated because of the abnormal thinness of the shells. To save the developing chicks, a sterile water solution was injected into the eggs, replacing the lost fluids. The shells then were sealed with a waxy covering to prevent further fluid loss, and the eggs were put into incubation at the Santa Cruz lab.

The foster chicks, banded with USFWS bands prior to being "planted," were last seen active around Crater Lake, learning the ways of their kind, filling their niche in the ecosystem, giving pleasure to park visitors lucky enough to spot them in action,

and representing untold satisfaction to the members of the operation team.

The two viable eggs were hatched at Santa Cruz—both females. One of them (christened "Crater") has since been mated with a male falcon from Yosemite National Park (who fell 2000 feet from his nest to the bottom of El Capitan and survived). This pair will remain at the Santa Cruz facility as breeders—producers of eggs and fledglings that may figure in similar scenarios in the future.

The three agencies propose a repeat exercise in the spring of 1982 if the parent birds show up again. Falcons have a five-to-seven year reproductive span, and no one knows at what stage in that span the nesting site was discovered.

Santa Cruz Falcons

Falcons hatched at Santa Cruz are treated in a variety of ways, depending on their future roles. Some will be kept as breeders, some will be "fostered," (as described here), and some will be "hacked out," which means they will be raised by adults until they are five weeks old and then taken to wild sites for about five weeks more, or until they achieve independence.

All eggs at Santa Cruz are hatched in incubators. The young are fed with tweezers for three days; from three to seven days they are fed by falcons that have been imprinted to people so that they will tolerate close examination of the young. At one week, when the young can see a few feet, they are moved to chambers with natural breeding pairs. Birds that will be kept for breeding are put with captive adults until they are five to seven weeks old. For three months they are handled by humans to tame them and to reduce the stress of captivity, then released into permanent chamber homes. In this way, those that will be retained for breeding are conditioned to captive life, and those that will be returned to the wild are kept fit for wilderness release.

Wilderness, however, is not the only future for these birds. If they manage to maintain their toehold on the planet, and as wilderness shrinks, one promising falcon habitat is cities with their artificial cliffs and canyons and their exotic populations of rock doves (pigeons), starlings, and similar falcon prey.

Peregrines hunt only small birds that they can catch in the air. They dive with speeds up to 250 miles an hour from high above their prey, striking with closed talon "fist" in a mid-air explosion of feathers. Anyone who has ever seen the peregrine falcon in action is unlikely ever to forget it.

Once "at home" in cities all over the world (before global pesticides knocked down its populations) the peregrines are one of only five bird species that are found everywhere in the world. They still nest successfully in many European and African cities. Made famous by falconry over millenia of human civilization, the peregrines are bird-eaters and thus, like the fish-eating bald eagle, they stand at the end of a longer food chain than do most other species. This makes them much more seriously affected by DDT poisoning.

It was the alarming decline of the peregrine that aroused concern and led to clarification of the mechanics of chlorinated hydrocarbons such as DDT and their effects on food chains. And it was these studies that led, in 1972, to the ban on use of these pesticides in the United States.

Saving the few remaining individual birds, who carry within their genes the last "instructions" for replicating this dashing species, has been established by law (through the Endangered Species Act) as a national priority. Of intense interest to scientists is the place in nature that these birds fill—the role they play as indicators of the general health of the ecosystems within which all life, including human life, functions. As individual species drop out of ecosystem processes, the well-being and resiliency of the life support systems tend to sag correspondingly.

Major economic outlay for the rescue at Crater Lake was contributed by the Santa Cruz Predatory Bird Research Group, which receives its support mainly from private resources with some help from the University of California, the California Fish and Game Department, and the USFWS.

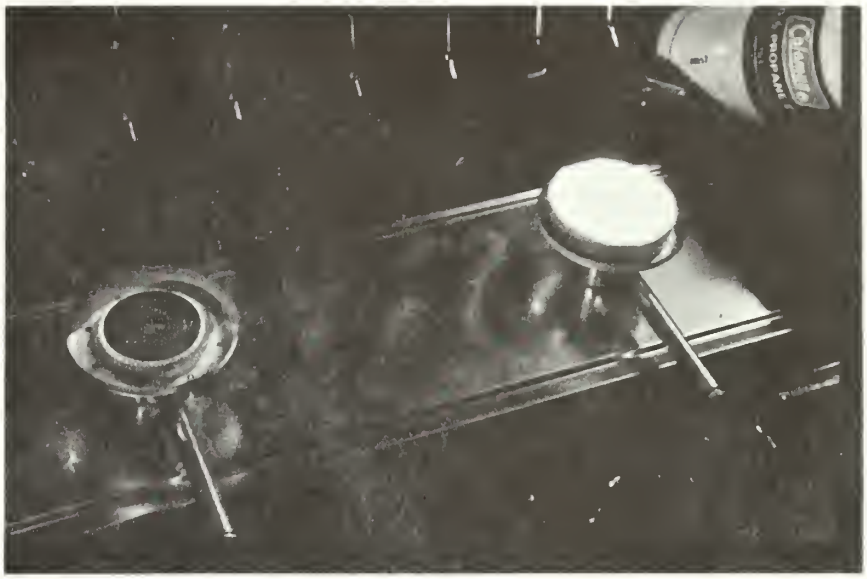
Jean Matthews is Science Editor for the National Park Service (Pacific Northwest Region) and is editor of PARK SCIENCE: A Resource Management Bulletin.

Catalytic Burn

by Theodore W. Sudia

National Park Service

Closeup of catalytic pile and its honeycomb structure.



National Park Service

This portable propane-fired stove has a regular flame burner on the left and a catalytic pile burner on the right.

There is nothing more romantic than a wood fire. Whether in the family room fireplace or in a park campground, the cheery blaze and warmth of the flames suggests our primordial kinship with all mankind through this most primitive and efficient fuel combustion system. What could be more satisfying than completing this act of returning the photosynthesized carbon dioxide and water back to the great cyclic wheel of nature?

Wood is such a convenient fuel. It grows almost everywhere, is convenient to cut, store, and use. Man, early in his history, brought wood fires indoors—first into caves, then into tents, huts, and houses. The fireplace and chimney replaced the hearth as the center of 11th Century English home life and finally, the Franklin stove providing an enclosed fire box to contain the fire, added great flexibility to the location of wood burning stoves.

In those places of the world where wood is the principal fuel, it provides heat not only for warming houses but for cooking food. Early steam engines and locomotives also burned wood.

Wood is an easy fuel to handle. It is clean, burns at a relatively low temperature, and has a pleasing smell when it burns—not the acrid, sulfurous smell of coal—but the fragrance of burning leaves, crisp fall days, the comfort of the campfire or blazing fireplace, the cheery crackle of the wood stove with its dancing orange glow in the mica windows.

In an energy conserving society wood seems the ideal fuel. It grows locally, it is biologically renewable, and it has eons of history as an acceptable fuel. In many regions of the western U.S., its availability and utility make it the only acceptable fuel. This is particularly true of many rural park areas where public accommodation facilities as well as park residences may be heated with wood. (In much park housing wood is the primary fuel source with bottle gas as the back-up fuel.)

What could be more idyllic than the National Park Service using wood as a fuel in these times of energy awareness? Wood is the ultimate renewable fuel and is *so natural!* But suddenly, today, a second look is called for.

What was simple in earlier times—namely the burning of wood—unaccountably has become complex. The principal characteristic of ecological thought—that nothing is as simple as it seems—is driven home in the case of wood burning.

Wood Substances

Wood ignites and begins to burn at 450°F. But wood is not a simple substance—it is in fact enormously complex, with cellulose, a long-chain polymer of glucose as its principal constituent (starch is a molecule with up to 300 glucose units—the cellulose molecule has more than 300 glucose units) and with literally hundreds if not thousands of other constituents—polymers of amino sugars, minerals, resins, gums, pitches and the like. With such a complex substance, only part of the material burns at the initial ignition temperature. Other parts vaporize, or distill and float away as smoke. Many of the ingredients of this conglomerate fuel *do* burn in the 450 to 700°F range, which is the range of temperatures of the average wood fire. But many of the constituents

will *not* ignite at temperatures less than 1200°F. Instead, they go up in unburned smoke.

And these unburned substances contain the bad news of wood fires, for among the constituents of the high ignition fractions of wood are creosote—a substance known to cause chimney fires—and to contain carcinogens—the same ones that cause cancer from cigarette smoking.

Pollution Problems

Principal culprits are polycyclic hydrocarbons, mostly of benzene. Wood combustion also produces the usual array of ordinary pollutants such as carbon monoxide, hydrochloric acid, the sulfur dioxides, and the nitrogen oxides. Sulfur oxides are formed from sulfur compounds in the wood, and since wood is typically low in sulfur— the sulfur oxides are not produced in abundance. Nitrogen oxides, however,are produced when nitrogen of the atmosphere and oxygen of the atmosphere react to form nitrogen oxide in the high temperature of the flame. So the higher the temperature of the flame the more nitrogen oxides. A really hot fireplace fire burns the creosote and makes the nitrogen oxides, creating a catch-22 situation. And of course wood smoke has lots of particles.

These pollution problems have ramifications not only for the environment outside the home but inside as well. Most homes with fireplaces have enough free ventilation that internal pollution is no problem. But homes heated with tight wood stoves of the "slow burn" variety create some hazard if not properly operated.

The outdoor pollution problem arises from the fact that everybody is doing it. In the Klamath Valley of Oregon and in the Missoula region of Montana, to name just two areas, wood smoke is a major pollutant. As more homes throughout the country convert to wood either as a primary fuel or to supplement expensive gas or oil, the problem will increase. This will occur simply because wood is available as a fuel and the stoves are available to burn it—both at economically competitive prices. Even industry is going to burn wood; a major steam/electrical generating power station is being built in the Burlington area of Vermont.

Catalytic Combustion

The technology that has been proposed to solve the pollution problem of burning wood is catalytic combustion. The fact that platinum wire will enhance combustion in a flame has been known for at least 100 years. The use of catalysts for a variety of chemical transformations has grown from that knowledge. The vast area of non-oxidative catalysts is at the basis of the petrochemical industry. Crude oil—a complex mixture of hydrocarbons is "cracked" in the presence of catalysts, and the cracked fractions are distilled into the products with which we are all acquainted—gasoline, kerosene, light fuel oils, etc.

Oxidative catalysis has recently been introduced into many pollution schemes. Perhaps the most widespread in the general population is the catalytic convertor that brings about the combustion of unburned fuel in the exhausts of automobiles. The convertor, a ceramic lined honeycomb five or six inches in diameter and several inches wide, is "washed" with platinum/palladium. In the presence of the catalysts, the very dilute fuel in the exhaust passing through the honeycomb burns to carbon dioxide and water—harmless products of combustion instead of complex hydrocarbons that cause so much trouble in the atmosphere. The combustion occurs at a relatively low temperature so most nitrogen oxides are not formed in any abundance.

This same technology has been adapted whole cloth to wood burning stoves. Honey-combed ceramic bodies with channels as much as ¼" on a side, washed with platinum/palladium, have been placed in the exhaust of the wood stove with somewhat mixed results to date.

What was not realized (nor did it matter in the automobile convertors) was that the combustion of unburned engine fuel was a high energy heat source. The main aim of auto manufacturers was to get rid of the fuel exhaust pollutants—not to get another onboard heat source. Unfortunately, that philosophy carried over into the stove business—where, however, the production of heat is the primary "raison d'etre" for the stove. So while the catalytic convertor *worked* for the wood stoves, they may have worked *too well*. With some unexpected results.

Catalysis

A slight detour into catalysis is required at this point.

Catalysts cannot make chemi-

cals react in ways they would not react without the catalyst. What the catalyst does is 1) lower the temperature at which the reaction takes place, 2) makes the reaction go faster—sometimes by orders of magnitude; and 3) withstands its own consumption in the reaction. Ceramic catalytic convertors can add a spatial component to the properties of catalysts. This is extremely important since it is possible to place the catalyst on a ceramic body (of any shape) or to place it on beads or wires, and thus control with great precision the "shape of the burn." The catalyst mediates the burn. Combustion occurring on the surface "washed" with a catalyst such as platinum does not burn with a flame. Presumably, the catalyst splits the oxygen molecule so that combustion proceeds with atomic, not molecular, oxygen. This is the reason that a catalyst can cause the combustion of such dilute fuels as are found in the exhaust of an automobile.

Catalytic combustion may not improve the combustion efficiency of an efficient fuel such as natural gas, but because the catalyst can be placed onto almost any shaped ceramic, it will greatly enhance heat transfer. In the case of wood, the catalysis does indeed increase the combustion efficiency of the wood, by lowering the ignition point of the fraction that normally goes up in smoke, and burning it.

The "mixed results" earlier referred to stem not from failure of catalysis as a heat exchange enhancer and a pollution suppresser, but from errors in stove design. By placing the catalytic convertor in the "exhaust" of the wood stove the designers of these stoves have essentially "flooded" the catalyst with fuel and allowed the hot gasses thus produced merely to escape up the chimney. In wood combustion roughly half of the fuel is consumed in a normal fire—the fraction that burns between 450°F. and 700°F. The fraction that burns above 700°F goes up the chimney. In the early experiments, stoves equipped with catalytic convertors overheated dangerously, threatening to burn down the buildings that housed them and sintering the ceramic body of the convertor.

At the same time, a most important and belated discovery was made: the burning of the smoke that normally went up the chimney was greatly increasing the heat output of such stoves.

It became necessary to stoke these stoves differently and to devise convertors somewhat different from the automobile convertors which had been used in the earliest stove equipments.

These catalytic convertor equipped stoves do decrease pollution. They reduce creosote remarkably and they increase heat output remarkably—but for these early stoves the new heat increment simply goes up the chimney.

What is still called for is a new approach to wood burning. The old stoves can perhaps be adapted to the new concept of wood burning; but new stoves can be designed to take full advantage of the possibilities offered by catalytic combustion.

Two questions await answers:

First, the question of wood as a fuel; and second, the type of apparatus (stove) needed to properly combust such a fuel.

Wood is an extremely complex substance that, when subjected to heat, partially oxidizes and partially fractionates (distills). Wood alcohol has been produced from time immemorial by the destructive distillation of wood. In its simplest form the *efficient* wood fire has to be a *staged burn*—with the low temperature fraction burned normally, and the high temperature fraction burned catalytically. This would be accomplished by lowering the ignition temperature of high temperature fractions to the range of the low temperature fraction, and burning both at about the same temperature. This is what the catalytic convertors in the stoves designed for pollution abatement do.

But, (and its a big "but")—the combustion via catalysis has some different properties than a normal wood fire. The principal one is the ratio of oxygen to fuel. In the presence of the catalyst, combustion is supported efficiently with as much as seven times more air than a normal fire. That is to say, the catalyst is efficient in oxidizing the fuel diluted by seven times more air than the normal fire. Under such dilution a normal flame would simply go out.

However, as the air in a normal wood fire is increased (by opening the draft) the low temperature fraction of the wood burns more rapidly, producing copious quantities of high temperature fuel which are readily burned at the catalyst. This second stage is so efficient that the heat release may be enough to melt the ceramic body of the convertor. This is exactly what happened to a wood stove equipped with a

catalytic convertor at the Eisenhower farm at Gettysburg. The ceramic body was sintered, rendering the catalyst useless.

It is obvious that wood must be subjected to "staged" combustion and that the conditions for the low temperature fraction are different from those of the high temperature fraction. The air-to-fuel ratio for the non-catalytic lower fraction has to be considerably lower than the air-to-fuel ratios for the higher temperature fraction. The strategy of the wood burning stove must encompass the concept of the wood as a *source* of fuel—*not as the fuel per se.* What this means is that the initial distillation of the wood to produce the fuel for the catalytic stage must be thought of as *a separate process with its own conditions.*

Relatively small quantities of wood have to be combusted at mild heat (around 450°F) and produce whatever heat can be produced at that level. The ratio of air to fuel should, in this first stage, favor the production of fuel; this fuel, then, should be fed in measured quantities to the catalytic stage.

The catalytic stage of the combustion should be precisely regulated so that the air/fuel ratios favor the catalytic reactions. In this case much more air will be required than the normal combustion, and the combustion will be much more complete. Regulating the rate of flow of fuel at the catalytic stage will regulate the heat release—with enormous potential, since enough heat could be released at this stage to melt the ceramic.

To adapt this concept to the stoves currently on the market—it will be necessary first to consider the loading of the stove and the draft setting. The technology of catalysis would favor slow burning stoves which were relatively air tight and which essentially kept a low temperature, almost flameless fire going. This type of stove would produce the higher temperature burning portion at a lower rate and would not overwhelm the catalytic convertor. A normal wood stove with a cheery blaze is simply going to flood the convertor with fuel and melt it. No stove currently on the market has been designed to take advantage of the catalytic convertor's potential to increase the efficiency of heat transfer from the oxidation of the fuel to the atmosphere of the room to be heated.

Conclusion

With as much activity as is present in the wood stove industry, it is only a matter of time until a wood stove with the capability to take advantage of the potential heat efficiency and non-polluting combustion of wood will be designed. When it is designed, it will consist of a two stage burner, where the first stage combusts some of the fuel, but *more* importantly, generates fuel for the second stage—the catalytic stage. Both stages will be engineered to transfer heat to the objects in the space to be heated and not send the bulk of the heat up the chimney as hot air or unburned fuel.

The most ancient of fuels and the most romantic of fires are rapidly making their way back into our lives. The marriage of this ancient wood burning technology with catalytic combustion is a worthy and welcome addition to our life style which dictates that we form a symbiotic system with our environment and the living things that share it with us.

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Can Signs Help Visitors Control Their Own Behavior?

By Richard K. Ormrod and Richard G. Trahan

Richard G. Trahan (UNC)

Hikers discussing possible hikes at trail head.

Within the context of overall sociological research and the tools it offers park management, the following specific research, conducted by two University of Northern Colorado scientists under a contract with Rocky Mountain National Park, is presented as a case in point.

During the summer of 1977, an experiment was conducted in Rocky Mountain National Park (Colorado) to determine if informational signs could be used as a means of controlling day hiker traffic in heavily used areas of the park. This attempt to test a specific recreational management technique was the offshoot of a more comprehensive study of day-use patterns in the park.

The larger study (by Trahan) focused on day hiker reactions to the numbers of other persons using the park's trails and to possible day-use limitations systems. Concern with such systems by the National Park Service stemmed from the tremendous increase in numbers of visitors using Rocky Mountain NP. (The number of visits had increased by 1 million between 1968 and 1977.)

Hiker Questionnaire

The primary research instrument for the Trahan study was a questionnaire given to hikers using a number of the park trails. One possible way of limiting day-use on trails, suggested to hikers on the questionnaire, was the use of signs to identify heavily used trails. It was felt that if hikers knew which trails were most heavily used, many would decide to avoid those trails, removing some pressure and directing hiker attention to lesser used trails.

This traffic control strategy was viewed positively by most respondents to the day hiker questionnaire (36 percent "strongly favor" and 44 percent "favor"). Because of the preference indicated for this strategy and because it represented a possible low cost, non-coercive means of controlling hiker flows on heavily used trails, an experiment was conducted to test its effectiveness.

Sign Usage

Research design involved placing signs at the junction of two similar trails. Several types of trail usage monitoring were undertaken to assess the impact of the signs. Lake Haiyaha and Emerald Lake trails were chosen. These two trails branch at the foot of Dream Lake, lead to rather similar destinations (alpine lakes), and are of approximately equivalent length. In spite of these similarities, the Emerald Lake trail was the more heavily used. A majority of hikers (60 percent) using the trails were exploring this area for the first time.

Signs were placed at the trails' junction informing hikers that usually there was more traffic to Emerald Lake. The signs were constructed with National Park Service aid and designed to blend as much as possible with other signs in the park. Two different versions were prepared and used during two different time periods to determine whether differently worded messages had different levels of impact on the hikers' trail decisions. One sign was "positively" worded; the other, "negatively" worded.

The positive sign encouraged use of the lesser used trail (to Haiyaha) by pointing out its attraction; the negative sign discouraged use of the more frequently used trail (to Emerald) by pointing out its more crowded condition. Each sign was placed at the trail junction for approximately one week, during which trail use was monitored. In addition, for a one-week period *both* signs were placed at the junction. Trail use for this period also was monitored.

During these test periods, hiker behavior at the junction was observed, optical counters were placed on the trails, and interviews were conducted at one of the trail destinations. Members of the research team directly observed and noted hiker response to each of the signs at the trail junction itself. The optical counters, placed on each trail with the assistance of Rocky Mountain NP personnel, automatically recorded a tally of trail users. Care was taken to see that as closely as possible the trail tallies represented hikers entering each trail at the junction and then returning on the same trail.

Richard G. Trahan (UNC)

Positive sign by bridge at trail junction.

Richard G. Trahan (UNC)

Electronic counter mounted unobtrusively on tree.

Interviews were conducted at Lake Haiyaha during each test period to obtain a more direct measure of the signs' effect on hikers' decisions. One member of each hiking party was asked several questions about the group's decision. Specifically, each group was asked whether its members had definitely decided to visit Lake Haiyaha before they left the parking area; whether they had seen the sign (or signs) at the trail junction; whether the sign had affected their decision to hike to Lake Haiyaha, and if it had, in what way.

Several positive results emerged. The signs were read by nearly all hikers who reached the junction. There, the signs stimulated discussion among hikers and raised the "crowding issue" as a point in making the trail decision.

Hiker Traffic Patterns

A comparison of the hiker tallies for each trail during the test periods indicated a change in traffic volume, with an increased percentage using the Lake Haiyaha trail when the signs were in place. (See Table 1.)

Initially, traffic volume was measured without the signs in place; it was found that 30 percent of total hikers used the Haiyaha trail. For the period the positive sign was in place, no change occurred in this pattern. This was considered surprising, since the interviews indicated a stronger influence from this sign than from the other. When the negative sign was in place, the usage rate of Haiyaha trail rose to 36 percent; when *both* signs were in place simultaneously, the Haiyaha trail usage rate went up to 42 percent.

Although there was a generally positive change in the volume of traffic on the Lake Haiyaha trail, it was concluded that the change could not be reliably linked to the influence of the signs. Since most persons were traveling with others, the numerical count does not directly reflect the actual number of alternative *decisions* being made. Furthermore, it was noted, during observation of the hikers on the trails, that the sizes of groups hiking together varied greatly.

Thus, a *single* decision to use one or the other of the trails could have resulted in one large party passing one of the trail counters and registering a significant change in the traffic flow patterns. Since daily rates for both trails averaged from 250 to 300 hikers, the proportions could be rather easily changed by the decisions of one or two larger groups.

In addition it was found in talking to hikers along the trail that a number of them visited both destinations—hiking to one lake, returning to the junction, and then hiking to the other lake. Thus, the increase in percentage of hikers visiting Lake Haiyaha *may* be related to the influence of the signs but this relationship cannot be conclusively shown.

Interview Responses

The interviews of hikers arriving at Lake Haiyaha give a more direct indication of the influence of the signs (See Table 2). Of a total of 107 persons interviewed during the three different test periods, 57 (or 53 percent) said they had not made a firm decision to hike to Lake Haiyaha at the time they left the parking area. It was anticipated that this group, representing hikers who had not made a mental commitment to either destination prior to arriving at the trail junction, would be the hikers most likely to be influenced by the informational signs. Of the 57 uncommitted parties, 26 (or 46 percent) indicated that the sign (or signs) had influenced their decisions to hike to Lake Haiyaha.

Furthermore, eight parties who indicated that they already had decided on Lake Haiyaha as a destination before arriving at the junction, said they were influenced by the sign (or signs). Presumably, the effect on those eight parties was that of reinforcement or positive confirmation of their original decision. Altogether, 34 persons (or 32 percent of the total interviewees) admitted that they were positively influenced by the sign (or signs).

The interviews were conducted at three different times: once when the positive sign was in place, once when the negative

Positive Sign	Negative Sign
SEEKING SOLITUDE? THIS PLEASANT TRAIL TO DRAMATIC LAKE HAIYAHA OFTEN HAS FEWER HIKERS.	WANT TO AVOID THE CROWD? THE TRAIL TO EMERALD LAKE IS OFTEN THE MORE HEAVILY TRAVELED.

Table 1. Hiker Traffic Patterns.

	Average Daily Number Hiking to Emerald Lake	Average Daily Number Hiking to Lake Haiyaha	Average Percentage of Total Hikers Going to Lake Haiyaha
When no Signs in Place	243	104	30%
When Positive Sign in Place	277	120	30%
When Negative Sign in Place	252	140	36%
When Both Signs in Place	159	117	42%

Table 2. Interview Responses of Hikers Arriving at Lake Haiyaha

	Sample Size	Number Admitting Influence by Sign(s)	Number Indicating Lack of Destination Commitment	Number of Uncommitted Admitting Influence by Sign(s)
Positive Sign	37	16 (43%)	20 (54%)	11 (55%)
Negative Sign	39	6 (15%)	21 (54%)	6 (29%)
Both Signs	31	12 (39%)	16 (52%)	9 (56%)
Total of All Samples	107	34 (32%)	57 (53%)	26 (46%)

sign was in place, and once when both signs were in place together. A comparison of the results from the three different samples indicates that the differently worded signs and the change in display from a single sign to both signs had different levels of impact on the hiker's decision (Table 2). The positively worded sign showed the strongest impact: 43 percent of all the parties questioned at that time admitted being influenced by the sign, while 55 percent of the uncommitted parties in that sample were influenced.

When both signs were in place at the same time a similar pattern of response was found: 39 percent of all the parties questioned at that time admitted being influenced by the signs, while 56 percent of the uncommitted parties in that sample were influenced.

However, the negatively worded sign showed a much weaker impact: only 15 percent of all parties questioned at that time admitted being influenced by the sign, while 29 percent of the uncommitted parties in that sample were influenced. It seems that positive phrasing aimed at attracting hikers to a particular trail is more effective than negatively phrased messages aimed at discouraging hikers from using crowded trails.

Conclusions

After careful analysis, it was concluded that the use of informational signs as a technique for influencing hiker traffic patterns is worth applying, since: (1) a positive impact was demonstrated; (2) it is a low cost and noncoercive approach, and (3) it does provide a service to the subgroup of hikers who are particularly sensitive to the numbers of other hikers they meet along the trail. (Responses on the day hiker questionnaire indicated that the majority of hikers had *some* sensitivity to numbers of other hikers on the trails.) Because the strength of influence of the signs was not clear-cut (and definitely not over-powering), this strategy cannot be recommended as a primary solution to the problem of over-crowded trails. However, it could be a useful complement to a package of other traffic control strategies.

Dr. Richard K. Ormrod and Dr. Richard G. Trahan are University of Northern Colorado faculty members in the Departments of Geography and Sociology, respectively.

Monitoring Visitor Use for Interpretation at Urban Recreation Sites

by Donald R. Field, Darryll R. Johnson, and James Gramann

The conduct of visitor use studies at recreation sites became commonplace on federal lands during the 1970s. This work was enhanced and supported by research organizations or programs within such federal agencies as the U.S. Forest Service and National Park Service. Numerous universities with sociology, economics and other social science departments, environmental institutes, forestry schools and recreation and parks departments found federal lands to be ideal study sites for supporting faculty and graduate research.

Less systematic attention has been given to the city as a focal point for understanding leisure behavior and the relationship of people to recreation places. Zoos, aquariums, museums, arboretums and urban parks, however, present noteworthy opportunities for understanding the nature of leisure in American society, leisure lifestyles and trends in recreation patterns.

Outdoor recreation within urban areas primarily is centered around park-going and associated forms of recreation at small urban sites within cities and urban neighborhoods. In a study conducted in the Pacific Northwest during the early 1970s, 45 percent of the population had visited at least one area managed by the National Park Service during the year of the study. However, 80 percent indicated use of local, county or state managed public open space and parks within cities and among county and state parks.

Interestingly, day-use by local and regional populations is the dominant pattern at most public parks. Limited information on visitation trends for the 1980s suggests that frequency of use at urban sites will not only continue, but increase as urban residents take advantage of recreation opportunities near their places of residence.

Discovery Park

Children build sand whale at Discovery Park's South Beach in Seattle (WA).

Economic Concerns

If the justification for acquiring information about who visits local recreation sites were simply that it documents preferences for one kind of recreation activity over another, then perhaps the inquiry could be labeled an academic exercise. But the need for this information is a management concern that goes beyond mere academic research. Many parks and public open spaces were established in an age of relatively abundant public funds, when government was willing to expend considerable monies for the purchase and maintenance of these areas. Such is not the case today.

Paradoxically, as demand for services in local outdoor recreation sites is increasing, support monies are decreasing. Closure or complete declassification of some sites is being considered. Instead of new facility construction, minimum facility maintenance is the funding level sought. Rather than adding new employees, staff cutbacks are being carried out. Clearly, in this cost-conscious scenario, knowledge of visitor numbers, visitation trends, and visitation patterns is a key management tool: first, in allocating funds to specific areas, and second, in the efficient design of site-specific programs.

This article reviews the idea of visitor monitoring programs for urban recreation sites. Five criteria for establishing visitor monitoring programs are discussed, then examples of visitor monitoring programs employed in resource management and interpretation are described.

Components of a Visitor Monitoring Program

Visitor monitoring programs are varied in kind and purpose. Each program designed has merits and limitations. Any successful program must have a specific objective, which in turn defines: (1) the nature of the information to be acquired; (2) specific well-defined measures (or variables); (3) how the information is to be acquired (i.e., a sampling plan—when, where, at what time); and (4) an analysis plan. Above all, the staff must be committed, disciplined, accountable, and systematic in application of the technique. The last point is considered first.

Staff Must be Accountable

It is pleasant to think that commitment to the organization and its goals or objectives guides employees actions. If an interpreter program manager defines systematically acquired information of the visitor as a key requirement to justify budgets, activities or standards, the task should be carried out with enthusiasm and thoroughness. This is not always the case. Each of us has a pre-defined concept of the role we fill. The superintendent may view his or her responsibilities as focusing on public relations, political constituencies and interorganizational relationships. Backcountry rangers may define their jobs in terms of miles hiked and knowledge/expertise about backcountry resource problems. Interpreters who are successful communicators and responsible for program planning may define their jobs around such tasks. Few positions in any organization have a requirement to collect, synthesize, and utilize visitor information in program planning. Few professionals currently accept this as an essential job responsibility and do so willingly. To be successful, a visitor monitoring program must be assigned to employees as an integral part of their job description.

Clear Objectives of Purposes for the Visitor Monitoring Program

A clear objective must be established prior to gathering the data. For example, is the data to be used to assist in budget formulation, to reschedule work assignments, to improve visitor relations, to improve communication with a clientele, to improve a park experience, to satisfy legislative requirements, or to document incidents of vandalism and visitor traffic? Failure to define adequately the study objectives is to invite devastating ambiguity as to how the information can be used. It can result in substantial effort being expended without collection of the data needed.

What Kind of Information is to be Collected?

Clear definition of a variable (or measure) relating to the information question must be established. For example, if knowledge of the geographical range served by an area is desired, perhaps zip code should be one piece of information obtained. In some cases, more than one measure of the same phenomenon may be necessary as a crosscheck on validity of individual approaches.

How the Information is to be Acquired

If the information is to be useful in planning or management, it must be acquired in a predetermined manner. The sampling plan (derived from the study objectives) is the procedure around which the information can be determined representative of a larger population—its importance cannot be overemphasized. In almost all cases where data is gathered, the interest is in making inferences to larger populations. Unless the sampling is random or deviates from randomness in a known fashion, such generalization cannot be reliably done. The result is a very limited use for the data.

What is the Analysis Plan?

The analysis plan depends on the needs for which the data were gathered. Do these needs require simple frequency tabulations or cross tabulations of information by key variables, such as visitor totals or visitor numbers by day of week or visitor numbers by day of week and hour of day? The intended analysis helps to define the precision required in the measures selected. For example, age distribution can be defined as actual age, by 5 or 10 year intervals or broad categories such as young, teenage, middle age, and senior citizen. It is crucial to think through the analysis plan prior to the actual acquisition of the data.

Discovery Park

Naturalist Lynne Givler conducts beach walk at Seattle's Discovery Park.

An Example of Visitor Monitoring Application of Needle-Sort System in Resource Management Agencies

A visitor monitoring program implies a purposeful plan of action to collect information on a clientele for some predetermined objective. A program can be designed to seek answers to a specific problem or issue, or as the basis for an ongoing process of information collection to support the continuing operations of a recreation facility. A visitor monitoring program can employ simple data management procedures or elaborate computerized technology.

Recently, the National Park Service and the U.S. Forest Service have experimented with needle-sort data collection techniques specifically designed as visitor and resource monitoring aids for individual park areas. Many of the systems tested can be applied in the field by agency employees in the course of normal work routines. Further, it is possible with each of these systems to retrieve and analyze data at the study site without recourse to outside assistance. Needle-sorting can serve as an "in-the-field" data processing system.

All needle-sort systems use an edge-punch card printed with particular information categories for which data are recorded on the card itself. Holes along the card's edges act as codes for each variable printed on the face. By inserting a needle through a particular hole in a deck of cards, all cards containing information represented by that hole can be retrieved from the deck for rapid analysis.

The following applications of the needle-sort technology to resource management problems and interpretation describe some relatively simple techniques that can be used to gather and analyze substantial amounts of information. There is no intent to suggest that the needle-sort approach is suited for all situations. However, accumulated experience with the techniques described below indicates that they would be well adapted to monitoring visitor trends in urban outdoor recreation areas.

Code-A-Site

The Code-A-Site System developed by the U.S. Forest Service is utilized to catalog the

biophysical status of established campsites, as well as to record the creation of new campsites along forest roads and in the backcountry. The task of collecting this information and entering it on specially designed needle-sort cards is carried out entirely in-house, using field personnel. Code-A-Site use in national forests is mandated by internal agency guidelines, and the information it produces serves as a partial basis for allocation of agency funds.

Its continuous use in an area from year to year makes Code-A-Site an effective resource monitoring tool, supplying information on trends in campsite development for dispersed recreation, in addition to "snapshots" of site conditions during any particular year. A proven aid to resource management, it fulfills many of the same functions as a visitor monitoring program by supplying needed input into the decision making process and by assisting in program accounting.

Human Impact Inventory

The success of the Code-A-Site System inspired a similar project in the National Park Service called the Human Impact Inventory. In this case, the intent was not only to catalog the physical condition of campsites in Olympic National Park (WA), but to assess over time the impact of human trampling on the vegetation and soils of these sites. Recording this information on needle-sort cards permits on-site storage and retrieval of the data in support of backcountry management decisions.

The Human Impact Inventory differs from Code-A-Site in that the relatively high level of precision and complexity required of its measurement restricts data collection to all but the most thoroughly trained personnel. Therefore, its employment, although in-house, is restricted to two or three skilled specialists. Even so, the ready availability of the data to administrators combined with the standardized manner in which information is observed and recorded, makes it an invaluable recreation resource management tool.

Codinvolve

The Codinvolve System developed by the U.S. Forest Service represents a different application of the needle-sort technology to the problems of resource management. Its purpose is to provide a systematic way for recording and analyzing the often voluminous public response to resource management proposals and environmental impact statements. Codinvolve has been popular with managers and, as with Code-A-Site, is often required by agency guidelines when public input is solicited.

Codinvolve enables resource managers to assign input on a given issue or management alternative to standardized categories. It facilitates processing large amounts of information immediately and efficiently. However, when public involvement analysis becomes complex, use of computers for more sophisticated statistical analysis is extremely beneficial.

Field Observation Guide

An example of needle-sort technology's use for monitoring changes in visitor characteristics is the Field Observation Guide, originally employed by the National Park Service in John Day Fossil Beds National Monument, Oregon. The Field Observation Guide is designed to record direct observations by park employees of visitor characteristics. However, it is useful also in recording visitor information volunteered during casual conversations with park personnel. The system monitors not only observable visitor attributes, but many non-observable traits and behaviors as well.

Systematic measurement of these characteristics and patterns is of use in support of area planning and program evaluation. Similar systems have been used in such urban NPS areas as the Gateway Arch in St. Louis.

Interpretive Activity Inventory

The Interpretive Activity Inventory is similar in many respects to the other systems described. One of the most thoroughly tested and evaluated applications of needle-sort cards to collect and analyze park visitor information, the system was designed to record data on audience characteristics during interpretive activities, and to document the

number and types of activities presented by park staff. It likewise can be employed to systematically record and store attendance figures for various interpretive programs, as well as to document those who do not participate in any programs.

For small areas the card could serve as a basis to census the visitor publics in an area at a given time, monitor changes there over time, measure attendance or non-attendance at specific programs, and identify the relative demand for one program over another — thus allowing evaluation of the entire interpretive effort.

The ability of the Interpretive Activity Inventory to measure changes in visitor characteristics and use patterns over time is especially valuable from an interpretive planning standpoint. In Mount Rainier National Park (WA), for example, information was collected that demonstrated interpretive walks designed especially for children were four times as effective in attracting children as walks designed for general audiences. Such systematically gathered data on audience composition forms a convincing argument for maintaining children's interpretation as an important component of overall interpretive programming.

Like the Field Observation Guide, the Interpretive Activity Inventory relies on direct observation and informal interviewing. This combination of strategies permits a greater variety of information to be obtained than would be possible using either method alone. Visitor residence, for example, must be elicited verbally. On the other hand, visitors may object to being questioned about their age, so this characteristic is estimated through observation.

In the case of the inventory, descriptive data is collected by those staff who have the greatest amount of interaction with park visitors, the park interpreters. The Field Observation Guide differs slightly in that it does not confine its data collection solely to interpreters, but uses all park personnel who regularly come in contact with the public. In small parks this does not make for a significant difference in the nature of the information gathered, but in larger areas confining data collection only to those people contacted by interpreters restricts the generalizability of findings to just one segment of a user population. However, the Inventory's emphasis on interpretive participants also simplifies data collection by limiting the amount and character of the data required to that having special value to interpretive managers.

Finally, the Inventory shares with all the preceding systems the use of the needle-sort card for the orderly recording and storage of its information. This means that each area utilizing the Inventory collects the same type of information, does it in a uniform manner, and is able to store it on-site for quick retrieval and analysis. Continual and immediate access to information is one of the basic requirements of any rational management activity. In addition, the availability of uniform data from many different areas or activities greatly expedites analysis and accelerates management processes.

Conclusion

The acquisition of social information may be increasingly important as the volume of visitors to urban outdoor recreation sites increases while dollars to meet program objectives decrease. Such information allows identification of visitation trends and visitor expectation and ultimately the efficient allocation of human and financial resources to maximize visitor satisfaction.

This article is excerpted from the forthcoming book *On Interpretation: A Sociological Reader for Advanced Interpreters,* to be published in the Fall (1982). The book contains a collection of articles and essays on sociological research in the field of interpretation and covers the decade of the Seventies.

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Fire Control

Designing Fire Programs for Parks

by James K. Agee

James K. Agee, NPS

Lightning is a major ignition source for natural fires in the western United States. Much of the forest pattern and structure in our western forests is due to disturbance at regular or infrequent intervals.

Any discussion of the evolution of our American landscape must include fire. Its influence has been significant and its effects have ranged from benign to catastrophic, depending on the natural environment and social objectives. Fire policy in most parklands has been to suppress all fires. However, this strict protectionist attitude has changed over the last 20 years as managers began to evaluate the long-term effects of such policies. Today national, state, and local parks are integrating fire into more clearly defined land management objectives. Prescribed fire, which is fire resulting from ignition by persons or natural causes to achieve specific objectives, is often a part of these revised fire management programs.

Prescribed Fire

The use of prescribed fire depends on the outcome of the fire planning process. Park management objectives are an essential initial element. For example, in parks managed for natural values, allowing lightning fires to burn may be a feasible option to perpetuate a natural distribution of community types and structures. Scheduled ignitions might be used to simulate naturally occurring fires if the use of natural ignitions is not feasible.

In a park managed for historical values, maintenance of an historic landscape may be the appropriate goal; total fire suppression or scheduled ignition prescribed fire may be the more desirable options. Park management objectives help define ecosystem management objectives, from which fire management planning can proceed.

Fire Planning

The elements of fire planning are simple in theory but often complex in application. After evaluating park management objectives it is necessary to determine the natural role of fire in the park, and then evaluate this role in terms of social, legal, economic and cultural values, and the current state of the ecosystem. Because fire can potentially affect surrounding lands (fire escapes, smoke), external impacts also must be considered.

Research may be needed to determine fire history and potential effects. Some agencies employ experts who can conduct appropriate studies or arrange for contracted research. In many subject areas, however, a considerable amount of research has been done that may directly apply to the park. A tremendous volume of fire literature has been catalogued by FIREBASE, a fire user's information system developed by the Boise Interagency Fire Center (ID). Annotated citations from keywords given to the computer are available at a relatively low cost.

Another source of fire effects information is the National Fire Effects Workshop held in 1978 and published as USDA Forest Service General Technical Reports WO-7 to 13. Individual state-of-knowledge reviews on soil, water, air, flora, fauna, and fuels are available, as well as environmental impacts of fire management which may be obtained from the college of Forest Resources, University of Washington. Due to the wide range of ecosystems and fire frequencies and intensities, few generalizations are possible, and site-specific interpretations should be made with the help of a specialist.

James K. Agee, NPS

Fire intensities are characteristically low in some forest types and high in others. The crown fire behavior in this subalpine forest has helped to create a meadow which will be heavily utilized by elk for the next 50 to 100 years.

Once the effects of various options are considered, more detailed planning should be done by a qualified fire specialist in coordination with other specialists. It should include evaluations of (a) fire history, (b) fire effects, (c) current ecosystem conditions, (d) desired ecosystem conditions, (e) prescriptions to get from current to desired conditions, and (f) implementation. For example, if current conditions are desired conditions, and fire plays a significant role, a natural ignition prescribed fire program is feasible. If current conditions are not those desired, planned ignition prescribed fire will be more appropriate.

During this time, public involvement will be important. Many agencies have developed fire interpretive brochures to explain the role of fire, the planning process, and the specific fire management plan. Several representative examples include the USDA Forest Service's *Life by Fire* (East Coast) and *Forest Born of Fire* (Rocky Mountains), and the National Park Service Cooperative Park Studies Unit's *Fire in Pacific Northwest National Parks* (Pacific Coast).

Fire Application

The best plans are useless without skillful application. Fire behavior is a function of fuels, topography, and weather. While the first two are relatively fixed in the short run, weather can vary dramatically during a prescribed fire. The fire prescription must take this into account by the use of natural or constructed fire barriers, firing techniques, and other options. Flexibility in the prescription is of paramount importance, but the allowable degree of flexibility can only be determined by the experienced and well trained fire team.

The National Wildfire Coordinating Group, of the Boise Interagency Fire Center consisting of Federal and State fire specialists, has recently published a job qualification guide for prescribed fire. The training required for these qualifications is available through various university and agency courses. For example, in the western United States, strong academic fire programs are available at the University of Washington, University of Idaho, University of Montana, and Colorado State University. Agency training has been available through the Interagency Fire Training Centers at Marana, Arizona and Redmond, Oregon. The Forest Service has recently begun its Fire Institutes, regionally-based programs for agency fire people, through cooperating universities. One of the most innovative programs is the California State Parks fire certification program, where fire program managers receive classroom training followed by 60 days of burning experience in the field.

Several key operational aids have been developed in the last decade. The most significant is the National Fire-Danger Rating System (published as USDA Forest Service General Technical Report INT-39), which supplanted the numerous regional or state-based systems and is now used across the United States to rate fire danger. Manual computations or computers produce "worst-case" index ratings of fire spread, intensity, occurrence, and severity for a given day. Field predictions of fire behavior also have been aided by the development of a hand-held calculator which, based on fuel type, fuel moisture, slope and wind, will predict the behavior of a headfire. These tools supplement, but do not substitute for adequate fire training and experience.

The successful fire program is one which works and is communicated well to neighbors and the public. Fire monitoring and interpretation are important here. Monitoring fire behavior and effects enables intelligent evolution of a fire program. Continuing education about fire is especially important for new programs and can be a valuable part of a visitor's experience to a park. Interpretive tools have included slide-tape programs, visitor center displays, brochures, and mobile interpretive talks on or near on-going fires.

Keeping Up-to-Date

Progress continues to be made in both fire research and fire management. Forest Service research is periodically reported through its forest experiment stations; three subunits of these, the Northern Forest Fire Laboratory, the Riverside Forest Fire Laboratory, and the Southern Forest Fire Laboratory, are concerned primarily with fire research. The National Park Service (NPS), Bureau of Land Management (BLM), and Fish and Wildlife Service (USF&WS) have smaller, less centrally operated research facilities, but certain regional units such as the BLM's Alaska Area Office, the NPS's Cooperative Park Studies Unit at the University of Washington in Seattle, Yosemite National Park, and the South Florida Research Center in Everglades National Park do have continuing fire research programs. All will send literature upon request.

A good management journal is *Fire Management Notes*, a quarterly publication of the Forest Service, in which progress in research and management is summarized in short articles. While every fire program does not require innovation, all will benefit from early adoption of new approaches in the field.

Fire has been an important influence on America's wildlands. Where this influence is a desirable objective of management, prescribed fire can be a valuable tool. Using established information networks for fire planning and application can aid the park manager in developing a successful fire program.

Dr. Agee is a research biologist with the NPS/CPSU, University of Washington, Seattle.

Fires on Florida's Merritt Island Bring Interagency Response

by Jack de Golia and Craig L. Rieben

The summer of 1981 will be remembered as a long, hot one on Florida's Merritt Island. A record-setting drought and unusually dry lightning storms combined to bring about a rash of wildfires to the Merritt Island National Wildlife Refuge, located on the world famous Kennedy Space Center. Over 16,000 acres of the 140,000 acre refuge burned during the summer.

Winds generated by the thunderstorms whipped flames into fire storms which literally raced through the tinder-dry subtropical brush, palmetto, and cabbage palm. On one summer afternoon, a dry lightning cell swept across the refuge and left 15 fires burning in its wake. The 10 local Fish and Wildlife Service staffers found themselves hard pressed to fight the unprecedented fires. Tragically, two refuge workers, Beau Sauselein and Scott Maness, were overcome by a fire storm and killed.

Tony Bonnano, NPS

A Forest Service air tanker (a p2v) is refilled with slurry on the 3-mile-long space shuttle landing strip.

Fire-fighting Resources

Refuge Manager Steve Vehrs called for help. It came in the form of fire crews, equipment and fire management specialists from three federal agencies and the Florida Division of Forestry.

In July, a 10-man crew of fire fighters came to Merritt Island from the Boise Interagency Fire Center (BIFC) in Idaho. Forest Service pumper crews and tractor operators came from the Apalachicola, Ocala and Osceola National Forests in Florida. And a fire boss from North Carolina and a line boss from Kentucky came from the Forest Service to take charge of the fire fighting operations.

In August, as more support was needed, the Forest Service "overhead" team was relieved by Les Tschohl, a fire boss from the Bureau of Land Management in Phoenix, Arizona, and a team of support specialists from BIFC, the Forest Service in Arkansas, and Bureau of Land Management (BLM) offices in Arizona, New Mexico, and California. Additional fire fighters from the Sumter National Forest in South Carolina also joined the roster. The National Park Service was represented by personnel from the nearby Canaveral National Seashore, as well as a team of five rangers from the Blue Ridge Parkway in North Carolina, who came to handle law enforcement. More fire fighters came in from several national park units in California.

Jack de Golia, BLM

A tractor and disc plow make a fire line in the Southeast.

When operation reached its peak, a total of more than 60 persons were involved. As these "outsiders" handled the fire fighting chores, the overhead team conducted training sessions on fire behavior and basic fire fighting for the local refuge and park people.

A small page of fire-fighting and aviation history was written during the fire emergency as air tankers carrying fire retardant slurry used NASA's space shuttle landing strip. The three-mile long strip is one of the shuttle's alternative landing sites which someday will be used routinely for landings from out of this world. But in the hot dry summer of 1981, the air helicopter, used for reconnaissance flights, also was based there, thanks to NASA's cooperation.

In mid-August, Les Tschohl returned to Phoenix and the duties of fire boss went to Dusty Voss from BLM's Los Cruces

Jack de Golia, BLM

Weary fire fighters take a break in the heat and humidity.

District office. He was assisted by Cap Jacques from BIFC. During this time the weather remained hot and dry with little hope of rain.

But a tropical depression which was to become known as "Dennis" was forming far to the south. Fire fighters anxiously tracked the storm's progress northward. Eventually, "Dennis" went right over Merritt Island, leaving only .19 inches of rain and making no impact at all on the critical fire situation.

As approximately 20 of the local park and refuge people completed an intensive three weeks of fire training, the interagency support force was reduced accordingly. But equipment was added in the form of a recently developed Water Expansion Pumping System (WEPS) Unit, loaned to the operation by the Albuquerque District Office of BLM for the duration of the fire season.

The pumper unit uses a relatively cheap by-product of pulp mill processing mixed with water. When the solution is sprayed it produces a fire retardant foam. The amount of time the foam can be sprayed is approximately 10 times that of spraying plain water, and this helps in situations where no source of water is available on site. While detailed to the operation, BLM personnel accompanying the WEPS Unit converted the refuge's marsh buggy and three pumper trucks to the new system.

Controlled Burns

During the period following the visit of "Dennis," afternoon thunderstorms brought some rain and the fire fighters took the opportunity to conduct some controlled burns. In addition to maintaining the pine and flatwoods habitat, the burns also reduced the amount of dead vegetation and provided an opportunity for the local people to try out the knowledge gained.

As the project scaled down, its organization began to resemble that of a BLM District Office, with refuge and park personnel manning the fire lines, overseen by the BIFC fire fighters and fire management officer, Dusty Voss.

The overall goal of the operation was to suppress the fires in a way that maintained the integrity of the refuge and provided training under standards set by the National Interagency Fire Qualifications System (NIFQS).

Conclusion

It is likely that interagency responses to major fires will become more necessary. Seldom can one agency marshall enough fire fighters and support specialists fast enough. From BIFC to regional offices to particular parks, refuges, forests, and districts, the emphasis is increasingly on fighting fires with NIFQS-certified people, regardless of the agency they work for.

The long hot summer and fires on Merritt Island called for this approach. As the fire season ended, all fires had been put out safely with the exception of the two fatalities. The local personnel had received valuable training that could save their lives. The interagency approach to the crisis had worked and all involved were hoping that succeeding summers would not be repeats of the summer of '81.

Jack de Golia and Craig L. Rieben are Interagency Fire Information Officers at Merritt Island National Wildlife Refuge, Florida.

Constitution Gardens Lake—The Ecological Connection

by John Hoke

National Park Service

Once a clear sheet of lifeless water, Bolivar Pond in Washington, DC, now contains the basic elements of a wetlands ecosystem.

Fourteen years ago, Bolivar Pond—across from the south (C Street) entrance of the Department of the Interior building—was a typical architectural reflecting pool, in a small triangular corner 'green' among one of many such mini-parks in Washington, D.C. Lined with ceramic tile giving it a swimming-pool blue color, it attracted relatively little attention, save that of the park managers that had to keep it clean.

Keeping it clean required scrubbing down about four times during warm months to get rid of unsightly and odiferous algae that flourished under a blazing sun in this seemingly lifeless liquid medium. A host of bottles, cans, paper, and other debris tended to collect along with the algae. These cleanup exercises were always costly.

Origins of a Natural Wetland Environment

The late Sixties was the time of burgeoning environmental movement; to make our urban environs less stark, cleaner, greener, more natural. In keeping with this trend, several Interior Department employees with a wildlife bent decided to enliven Bolivar Park by putting natural life in its pool.

With little advance notice, old logs were placed in the pond, along with planting boxes containing stands of cattails, water iris, and other wetlands flora. Floating water lettuce and hyacinth drifted about in ever-changing patterns.

Fish introduced into the pond included bluegills and gambusia—the latter were added to keep mosquitoes from joining the party. And lastly, a modest collection of water turtles was added. They soon became a focal point of the living pond while they basked in the sun in a linear array on the rustic log.

It was an instant success. Visiting tourists, local residents, as well as workers from the Department of the Interior and other nearby offices quickly chose this site as a place for a brown-bag lunch. The pool also attracted visiting wildlife; dragonflies, damselflies, and honey bees. Families of ducks naturally found their way through and over the nearby bustle of traffic, and so every spring in recent years a flotilla of tiny mallard ducklings have graced Bolivar Pond.

There *were* some detractors: Architectural specialists felt it did injury to many aesthetic and design objectives. An 'instant swamp' had not been a part of the original design, and there was the economic question: "Okay, so it's pretty. What did it cost"!?

Maintenance Costs

This query looked like bad news. After all, it HAD cost something to make the boxes, to find such things as the old logs and the turtles, and to pay for moving everything into place—so a cost comparison was made. The figures refreshened our enthusiasm: Even including the initial installation costs, that year's maintenance costs for the pond had become much lower, and they were to become even less with each passing year.

These raw numbers of maintenance costs are what sorted it all out. Mid-season "purges" at over $2,000 each were no longer required to get rid of the algal plagues. Once the new system got going, the ever-present algae would never develop to nuisance proportions. The algae thus became but another of the many life forms within the balanced ecological system. In time the system was left intact year 'round. Its maintenance costs then dropped to insignificant levels.

When trying new things, how often it is that we do the right things for the wrong reasons, and the wrong things for the right reasons. This time we managed to reverse the order and we came up with TWO right reasons as a bonus, but at first we missed one of them. While we had sought only to bring some of nature's grace into Bolivar Pond, yet another benefit was to join this: It would now cost much less to maintain. Given half a chance, Nature will take care of itself, if we will just include it in our plans!

Visitor Interest

There was even more benefit from our tactics! Less and less trash now found its way into the pool. Visitors to the pond did not feel inclined to 'trash' it, now that it was alive, and the 'home' of wildlife coming to live there.

The many whys and hows of these benefits sparked the interests of others in the Fish and Wildlife, and the National Park Services. The questions asked about what was happening in Bolivar Pond became so numerous, the Secretary's office asked that we prepare a small 'how-to-do-it' pamphlet to give those who wanted to do the same thing in other communities. It was called "Nature Downtown."

This newly enlivened wetland drew students from nearby schools. They took pictures and water samples so they might learn about the mechanisms at work in this in-town ecosystem.

Other nearby ornamental water bodies, such as Constitution Gardens Lake and the Reflecting Pool, now attracted our attention. Their frequent foulings with algae were really expensive to clean up. Whenever this happened in the big Reflecting Pool, it could involve as much as $20,000. On top of this could be repair costs due to any ground heaving damage caused by removing the weight of the water from the pool's masonry bottom and sides, while it was empty. The several-weeks' eyesore this created did not please the visitors. Could what we had done in Bolivar Pond be applied in these two larger water bodies?

Constitution Gardens

The nearby Constitution Gardens includes a six acre-plus lake, also intended to reflect the Washington Monument. Being an essentially lifeless, architectural pond, it, too, was often prone to being choked with unsightly strands, mats, and domes of filamentous algae. Maintenance forces, resenting its cleanup costs and manpower involvement, asked NPS resource managers to try 'moving' Bolivar Pond into Constitution Gardens Lake.

Once again we had to face the architects. Their ideas about what it should look like did not include beds of cattails and old logs, breaking the water and disturbing its reflective purposes. This led to a new ground rule: We were to create a living ecosystem able to take care of itself

National Park Service

Freshwater 'seaweed' - the underwater plants that would provide the first habitat mechanism for the ultimate growth of a healthy underwater ecosystem.

and control any algae living in it, but nothing would be allowed to emerge above the lake surface, i.e., our workings must remain unseen.

Controlling algae with chemicals had been an earlier option, but we now felt it was ecologically unsound—and set a poor example—for the National Park Service to periodically run its chemically-purged systems down the local drains into nearby waterways. Chemical use was not eliminated but was not to be the primary tool in our management arsenal. Our objective was to introduce more normal biological control mechanisms into the lake, and in doing so to provide another element of interest and enjoyment for the visitors to the park.

There would always be valid reasons to occasionally use chemicals to control some runaway pest, but we now sought alternatives, and this was a good place to try them. All of what was happening in Bolivar Pond was not yet fully understood, but it was felt that natural mechanisms were indeed taking care of its cleansing. Putting these forces to work in the bigger Constitution Gardens Lake would be a quantum step over standard chemical control methods followed earlier. We decided to give it a try.

Food Chain Process

Our resource managers, NPS Ecological Services Lab scientists and others shared the feeling that it was the 'food chain' process—a normal part of any aquatic ecosystem—that was probably at the heart of the Bolivar Pond successes. It would thus be important to establish an ecological system in Constitution Gardens Lake.

Paving the entire lake bottom with sediments and submerged swampland vegetation would be very expensive. But *seeding* the lake with shallow boxes of such selected materials should be enough to establish a rudimentary system able to increase itself in a reasonably short time. As the system matured, bottom silt would gradually develop. The plants in the boxes could then begin spreading across the lake floor.

Fifty 4x4x1 soil-filled boxes were planted with Potamogetum, Vallisneria, Elodea, Ceratophyllum and other such submerged aquatic plants, and then placed strategically on the lake floor. The lake was then filled with water.

But within a week algae growth appeared. We reluctantly drew down the lake water to box-top levels, and gave the remaining water a controlled dose of copper

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Five days earlier, this water in Constitution Gardens Lake was clear. Under a hot sun and in water that was loaded with nutrients and little other life, the algae was thus able to reproduce at its maximum rate.

sulphate to knock back the algae. Again, we re-filled the lake.

Still the algae persisted. We next darkened the water with nigrosine dye, a harmless agent able to block enough sunlight to thwart the algae but not arrest the growth of the new plantings, which, in the boxes, were closer to daylight, near the water surface. It was time for some second thoughts.

While we had installed the rudiments of an ecological system, we felt that micro-organism aquatic life was not yet present in sufficient numbers to do the job that we supposed it capable of doing. To beef up their numbers and variety we pumped in several 1000-gallon tank trunk loads of rich swamp-bottom muck from the nearby Kenilworth Aquatic Gardens. THIS should be sufficiently ladened with enough of the many life forms we sought to quickly establish—even in a five million-odd gallon lake!

This seemed to create the crucial mix. The algal blooms became less and less severe with each passing month, to where there has since been no need to purge the lake. From an economic point of view, the battle had been won, and handsomely.

Even so, we were still not quite finished. We wished to understand more about the mechanisms at work and thus be better equipped to hasten their effectiveness. We hovered over the system, pacing and plotting as many facts in their numbers as possible about the lake's water quality: pH, nitrogen content, temperature variation, and other such measurables were collected periodically and charted. But recurrences of algae in the early spring and during humid warm months seemed to humiliate our labors. One key element was to better manage excess nutrients in the water. Unless we could keep water nutrient levels low, while the newly-installed ecosystem developed to where it could begin to effect natural nutrient controls of its own, these algal blooms were to remain a problem.

But all we were doing seemed to provoke as many arguments as answers—such as where the excess nutrients were coming from. Some felt they were airborne. Others felt they were washing into the lake from the nearby landscaped grounds. Those handling the agriculture chores in Constitution Gardens felt strongly that run-off into the lake from their activities was NOT the source of suspected nitrogen concentrations. But the nutrients were there, and had to be controlled.

Thus, some changes were made in the fertilization of nearby land areas, including a switch from the use of chemical fertilizers to composted sewage sludge. It was felt the lower and less soluble material in the compost would be less likely to run off into the lake water during heavy rains. And its 'bulk' would be a good soil builder. In addition, much of the turf management activity was scheduled to be done during October which would minimize runoff water causing any risk of unbalancing the lake ecosystem.

Because we were trying to create the semblance of a natural aquatic environment in an otherwise unnatural urban concrete pool, few of us were yet quite sure about just what processes were at work in the lake water—which life forms were there, did what, and why. Much of what we did know was based on better-understood concepts of farm pond and natural wetlands ecosystems. We all agreed, however, that as the life we were adding to this new system continued to thrive and adapt and diversify, it would gradually lead to the more stable aquatic environment we sought; that we would normally associate with a natural non-urban aquatic environment.

Life Form Diversity

With an increase in the different kinds of life in the system, we felt there would be progressively less chance that any one life form could gain enough advantage to over-produce and overwhelm the other life in the system. In a healthy and diverse aquatic community, when nutrient levels occasionally increase, life forms that thrive on high nutrient levels cannot overwhelm the whole system by its own over-production because some other life form will be there to thrive on *it*, and thus eventually swat it back in line.

While we added more kinds of life—fish, frogs, and so forth—many a critter came on its own. Waterfowl now flocked to the lake. Since we now seldom drained, altered, or otherwise disturbed the lake water, the system has become increasingly attractive to waterfowl and other migrating aquatic life. We also

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The Maintenance staff of National Capital Parks/Central prepares the planting boxes that will initially house the underwater plants placed in Constitution Gardens Lake.

sought new ways to provide shore-based habitat such as plantings favorable as food and nesting sites for visiting waterfowl that would be compatible with the landscape features prescribed by the original architects of the gardens.

About this time our predictions were beginning to bear fruit. Left to itself the newly-installed ecosystem was maturing, and so it increasingly did its thing—the algal blooms became fewer and shorter lived. We felt we had reached a turning point in it all!

Reflecting Pool

By Fall of 1981 we were now surer of ourselves, and the number of 'surprises' diminished. One final challenge remained. A major restoration of the nearby Reflecting Pool was nearing completion—including a new concrete bottom, changes in the water-handling system, and reworking of the surrounding landscape. With Constitution Gardens Lake beginning to manage itself, the question again arose as to whether a similar system could be introduced in the even larger Reflecting Pool.

Its potential algal problems were the same, as well as its architectural constraints. Whatever was put in the water must not interfere with its monument-reflection purposes. The same type of planting boxes were used, but another even shallower box was also included. This was to accommodate a new submerged aquatic plant we had just learned about from Department of Agriculture scientists. Known as dwarf spike rush *(Eleocharis spp)*, agriculturists used it to impede wall erosion in Western irrigation canals, because it mats thickly in the soil. Even though it grows only about ten centimeters high, we were told it would outcompete with many other forms of aquatic vegetation. We saw it as another habitat candidate for small aquatic life forms but one that would be sure to remain below water surface levels. Flats of this rush were included with boxes of the same kind of vegetation introduced earlier into Constitution Gardens Lake.

With its collection of boxed vegetation, the Reflecting Pool was filled with water in mid-year, 1981. A dose of swamp-bottom muck was also pumped in, to provide the initial inoculum of micro-organisms.

During that first year, no algal bloom appeared—there was no need to drain and clean the pool—and so the costs involved in introducing the ecosystem were thus totally written off, with reserves to spare. We feel confident that by carefully monitoring its development during 1982, we can insure the same healthy progression we witnessed earlier, in Constitution Gardens Lake.

Our efforts to transplant elements of natural aquatic ecosystems into these urban settings still left us with insufficient hard mathematical or other scientific data that could conclusively explain all that was happening in the systems. Perhaps factors other than the ones we introduced were also contributory to controlling runaway algal growth, about which we would like to know more. But we *can* say that since these ecosystems installations were made, the three bodies involved became much less prone to abnormal algal growth.

This might well have been enough for the maintenance and site managers involved. The desired results had been realized because what we did worked, and thus reduced our maintenance costs. But it was not scientifically or intellectually satisfying to just leave it rest at that. It would profit us to have a more thorough understanding about the fundamental ecological processes involved which were at the very heart of our successes.

But because these successes appeared to be quite real, we now sought to quantify what was now happening in these ecosystems. A better education about the basic ecological happenings involved would make the results of our future efforts that much more predictable and effective.

We weren't overly concerned about these apparent 'holes' in our knowledge base. Until very recently, ecology, as a basic science, had been an amalgam of many specialized disciplines such as botany and zoology. Only in recent years have people begun looking at the environment as a whole, wherein pertinent aspects of single scientific disciplines were to become but a part of the newer scientific field—that of ecology. So it was not surprising that a scientific exactitude about what was going on in the ecosystems we sought to create was elusive. The facts were no doubt somewhere but they seemed to exist in the form of bits here, and pieces there—and crossed the boundaries of numerous fields of scientific specialization.

Sharing of Knowledge

There is in all this the hint of a new outlook that would be of

National Park Service

Staff of the Ecological Services Laboratory continually monitored the water quality state of the freshly planted Constitution Gardens Lake.

benefit to all our specialists—from park rangers, resource managers, and maintenance and site managers to the scientists. Since many jobs and scientific disciplines become involved when we more properly deal with our park environments as whole systems, we are going to find we each need knowledge elements that go beyond the ken of any particular professional expertise. The skills of others working within different disciplines must be tapped.

It's awfully tempting for some of us to feel that we can 'make it happen' all by ourselves—with our shovels, back-hoes and the many other tools and techniques we use to move earth and shape the living in it. The 'new outlook' proposed is simply that of seeking to know more about the other disciplines that might profitably affect our efforts—and to communicate more with those who possess them. An example will perhaps better explain this point.

While working in a commercial scientific research organization years ago, this writer observed that when the scientists of different departments broke for coffee breaks, lunch, or what have you, all the electronics-types would gather at one table, the chemists at another and so forth. Each discipline thus remained isolated from the others, though handily present, while these little groups of talent just sat around their tables talking to themselves. What went on at the next table was seldom heard. Even the company bowling tournaments were so segregated—Lab A's "Fireballs" pitted against Lab B's "Thunderbolts." Little breadth to their collective knowledge base could be developed in this 'club' atmosphere. Attempts to get these folk to mix it up with the other tables of talents were quite a challenge but whenever it did happen, it is surprising the 'new' knowledge that evolved from this kind of intellectual cross-fertilization—and the new products that ultimately evolved.

Park rangers, resource managers, scientists and so forth all have jobs where such cross-discipline contact can better equip them to cope with the environmental needs of our park resources. Science can play an even more potent role in the care of our parks, if our park technicians will become a little more science-sensitive—and look to other disciplines for new avenues of help and guidance, when faced with unexpected resource management challenges and problems.

Their job can be made worlds easier if they will include the scientists as being among those who can help them with their real-world problems. The scientists as well should seek to apply their expertise in such new areas, and show park managers that the road will be slicker not trying to go it alone.

The site manager wrestling with some problem can often best begin solving it by foregoing yet another round of meetings—or lunch and coffee breaks—with other office mates, and sit down instead, with the lab staff at the next table. Their contributions cannot help but be new ones!

Conclusion

For those few who may still question whether science can serve down-to-earth park management needs—or whether it is really important to know how an aquatic or parkland ecosystem works—here's a little bit of insight delightfully spelled out by H.G. Wells, when years ago he wrote one of the first science fiction stories—*The War of the Worlds.* In that story mankind was suddenly assaulted by alien beings from another planet. To save ourselves we tried every weapon and trick in the books, but we got clobbered at every turn by the invaders. But wholely unexpected allies also entered the fray—the micro-organisms that were also a part of the ecosystems of the world. What finally saved us Wells sums up succinctly in the final words in this book.

"After all that man could try had failed, the Martian invaders were finally conquered by the little things that God in His wisdom had put on this earth."

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Cooperative Park Study Units: A Study in Synergy

by James K. Agee, Donald R. Field and Edward E. Starkey

Universities are the sources of two kinds of research—pragmatic, problem-solving research and theoretical research. The former aims at providing answers for already-formed questions; the latter aims at something called "new knowledge," out of which arises new questions, which then tend to be turned over to the problem-solving branches of research.

The pathways through which applied research exits from universities are various. They include industries (which often fund the particular research in which they are vitally interested), extension services (which disseminate information to the public in areas ranging from home gardening to computer science), and—of specific interest to park management—something called CPSU's, which is short for Cooperative Park Studies Units.

This last route by which research is translated into application is the means by which the National Park Service can dip into the rich resources of University faculties, facilities, and student bodies to find out more about the basic nature of the National Park System, to study the processes that comprise the public trust for which the Service is responsible, and to acquire new insights into how people interact with parks—as visitors to the parks, as part "owners" of the parks, and as reactors to park management.

CPSU's now comprise a network of 35 active units nationwide. With a record of high productivity and low overhead, CPSU's are increasingly called upon to supply research-based information around which budget- and personnel-stressed management plans can be formulated.

National Park Service

Assistant Zoology Professor John Ruben watches as student Nancy Becker uses an air-scribe to clean away the matrix in which the bones of this "biting cat" were preserved.

The CPSU concept embraces the functions of teaching, research, and extension on a sustained, cooperative basis between universities and the National Park Service. The Units are designed to serve more than one park and to function at the national level as integrators of scientific activities for park management programs. In pursuit of these and other goals, the CPSU system contains numerous built-in reward loops for both the universities and the Park System (for which the Service was created). With both government and state (and hence, university) budgets stretched to the breaking points, the reciprocal reward aspect of the NPS/CPSU arrangement could easily lend itself to encompass other types of parks—state, county, and municipal—where the research needed for better management could provide work and learning experience for student researchers.

CPSU's were created and shaped by the needs they serve; they reflect the rewards sought by both partners in a symbiosis that has meant an exponential increase in the scientific resources available to parks and a similar widening of research opportunities for universities.

Isolation and under-use of park-based scientists—distressing to scientists and managers alike—provided the element of dissatisfaction out of which grew the 1970 agreement between the National Park Service and the Uni-

versity of Washington. The result was the first Cooperative Park Studies Unit in what, within the first decade, became a network serving the specific needs of 35 academic institutions and the parks lying usually within a day's drive.

CPSU programs usually are associated with professional schools or departments that emphasize the application of science to problem solving. Thus, research is oriented to specific single park problems in most cases, but some of the research has regional and national applications as well.

Cooperative Benefits

NPS scientists can be more productive because of better facilities and easy access to peer discussion and review of park research problems. They can keep the research efforts on the park track by reason of their specialized training in park problems, and at the same time exercise their generalist talents to coordinate research contracts with other faculty members whose special knowledge and capabilities would not otherwise be available to parks.

With dollars and energy in shorter supply, both cost and energy effectiveness have taken on increased importance in the overall scheme of park management. CPSU's have proven productive, cost-effective, and responsive. They have increased scientist productivity at what amounts to reduction or elimination of overhead costs on funds transferred to universities. The park-university science mix also has resulted in an increased flow of outside research support (e.g., National Science Foundation grants) for parks.

National Park Service

NPS CPSU Botanist Berta Yutie works with plant materials that have proven, through research, to be the most likely to succeed in re-establishing the natural plant succession that human activities disrupted on the present park environs.

Parks served by CPSU's benefit from the specialized help made available; the university CPSU program has been referred to as "a science staff of 200," reflecting the whole spectrum of university talents on call to the parks on a regular basis. The CPSU park scientist has at his disposal the university libraries, laboratories, computer facilities and the ideas, review, and criticism of the university science community. Parks served by the CPSU are thus able to receive specialized help in the broad range of possible problems, from wildlife science and forest fire management to the sociology of leisure and human ecology within park areas.

Nor does cooperation stop with the interaction between park and university scientists. Intra- and inter-regional cooperation is common. The Pacific Northwest Region's science program, which supports CPSU's at the University of Washington, University of Idaho, University of Alaska, and Oregon State University, also provides assistance to both the Western Region in California and Hawaii and the Rocky Mountain Region in Montana. This interaction between regions allows quick response to given problems by the best expertise available, without delay or redundancy. It also responds to the demands of society today to tighten operations, save all possible outputs and outlays, and "do more with less."

Extension Effort

Extension is an important element of CPSU activities, and again, this is completely compatible with the university connection. Training, publications, and review of various park action plans in the light of citizen understanding of park management decisions come under this heading. The hosting of park management related workshops, serving as faculty at NPS training centers and participation in interagency training programs such as the fire training center at Marana, Arizona, are examples. Others include local training opportunities for park personnel and for people in park-related disciplines.

In addition to hosting science/resource management workshops where research and its park applications are discussed and where park-based specialists can participate in short courses, the university-based CPSU scientist can advise park personnel of upcoming opportunities in degree and non-degree programs.

CPSU staffs have developed motion pictures, slide tape programs, and publications that

disseminate science findings. This material, for which no other outlet may be available, has generated Servicewide interest and approval from management within the National Park System. Examples are the 1979 publication *obtainable through the NPS/CPSU, College of Forest Resources (AR-10) University of Washington, Seattle, WA 98195* by Dr. Bruce Kilgore (formerly of the NPS Western Region) on the relationship between scientists and resource managers, and the 1980 paper by Roland Wauer (Chief, NPS Natural Resources Management), on the role of the NPS natural resource manager (see *Who You Can Turn To?*) The extension effort generally involves material unsuitable for journal submission but extremely pertinent to the science/management interface. It is intended specifically to translate research results into managerial applications. *Park Science: A Resource Management Bulletin,* published out of the Oregon State University CPSU and reflecting the total National Park Service research picture, is precisely targeted at this "translation" (from scientific findings to management applications) function.

Management Economies

"Cutback management" was a term that surfaced about a year and a half ago, and during its brief period of currency was viewed as a blessing, a disaster, and every discernable shade of in-between. *(See "Coping with Cutbacks," Trends Vol. 18, No. 2.)* Although the term quickly fell from usage, the condition it describes has hung around—a recognizable condition in parks everywhere, at all levels

National Park Service

Oregon State University Zoologist John Ruben leads a collecting trip at John Day Fossil Beds NM (OR).

of organization and administration. If it has any elements of a boon—to people and parks alike—it lies in finding the optimum mix of efficiency and effectiveness. The pruning of services must be accomplished with delicacy and precision; the stretching of all available resources must be done with vision and imagination.

CPSU input into park management is proving to be a tool for effecting the wisest economies and at the same time bringing every resource into fullest play. The always-on-tap nature of University facilities can provide for quick response to unforseeable situations.

As for wise pruning of services rendered, the measurement of bitterbrush use by deer at Lava Beds National Monument (CA) is a case in point. For the past 17 years, the park had been routinely collecting these data, and the data in turn had been collecting dust. Last year, Ed Starkey of the Oregon State University/CPSU, took the figures and coded them for a computer-based system of storage, retrieval, analysis and management use. He used the Oregon State University computers and key punch facilities to do this. This action made possible an NPS Western Region review of the information, weighing the possible suspension of such data collection in the light of its usefulness to park management. The CPSU analysis cost NPS $200; savings could run into hundreds of hours and thousands of dollars.

Two more cases illustrate the wide range of CPSU service applications and their acceptability to management.

At Fort Vancouver, decay was found in king and gate posts and in palisade pickets that had been pressure-treated with pentachlorophenol in mineral spirits. A wood preservation expert from the Oregon State University (available through the CPSU connection) went to the park, determined the exact nature of the problem, and prescribed a volatile fungicide that would control the internal decay. Surface decay, a more difficult case, requires further research, but interim control techniques have been recommended and Superintendent James Thompson is satisfied that "the stitch in time" could substantially add to the life of these wooden structures.

"We now know," he said, "how to prolong the life of this wood, and we know too that replacement today would cost at least 30 percent more than the original construction."

Jim recalled the help provided by University of Texas faculty and students on a contract basis to White Sands National Monument (NM), where he was superintendent from 1973-78. "They helped us manage kit foxes and carrion consumers," he said, "and gave us priceless advice in dealing with the Army over placement of a trench for the White Sands Missile Range. Put me down as a believer. Research pays off."

John Day Fossil Beds National Monument (OR) is the other case. There, in fossil beds that represent the longest-known continuous record of past life forms recorded by natural forces—eight million years worth, dating from 25 to 35 million years ago—the extended reward loops for both parks and universities in the CPSU connection are dramatically evident. Partially on the basis of the cooperative agreement between Oregon State University and the National Park Service, University zoologist John Ruben was able to get National Science Foundation funds to assemble a teaching collection of vertebrate fossils for the OSU zoology department.

Says John Day Superintendent Ben Ladd: "Ruben has located a number of fossils himself—a feat for which we didn't have the professional capability ourselves. He's a paleontologist as well as a zoologist, and he has used the Oregon State University lab, fully equipped for fossil preparation and replication, to produce exhibits that add immeasurably to the park experience."

The reproductions are being set up under plastic bubbles at approximately the locale where they were discovered, and Ruben is supplying the data for park interpreters to use in telling the story for visitors. Ruben is available to the NPS as a consultant on retainer, his services including full use of the University laboratories. Cost to the Park Service is $3,500 a year.

Conclusion

The history of Cooperative Park Studies Units is comparatively short, but its strong growth pattern suggests that science may at last have found its proper niche in the park management scheme of things. Historically, a research organization within the National Park Service has been notoriously unstable. Economic strictures and the demand from Congress for soundly science-based responses to the threats to National Park System integrity, together make the case for the strongest scientific research program in the most efficient delivery mode. The CPSU approach, then, would seem to provide a way of making scientific research at last an accepted component of the National Park Service.

This article was excerpted from a paper by James K. Agee, Donald R. Field, and Edward E. Starkey, "Cooperative Park Studies Units: University-based Science Programs in the National Park Service," that appeared in the 1979 Annual Science Report of the NPS Pacific Northwest Region.

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The following is a list of universities and related facilities with which the National Park Service has memoranda of understanding in conjunction with its Servicewide science program.

North Atlantic Region

University of Massachusetts, Amherst
City University of New York, N.Y.
College of the Atlantic, Bar Harbor, Maine
Rutgers University, New Brunswick, N.J.

State University of New York, Syracuse

New York Botanical Garden, N.Y. (WASO)

Mid-Atlantic Region

Pennsylvania State University, University Park

University of Virginia, Charlottsville

University of Pennsylvania (Morris Arboretum), Philadelphia

National Aeronautics and Space Administration (Wallops Island) (WASO)

Rocky Mountain Region

University of Wyoming, Laramie

University of Denver, Colorado (WASO)

Utah State University, Logan

Colorado State University, Fort Collins

Southeast Region

Western Carolina University, Cullowhee, N.C. (CPSU)

University of Georgia, Athens (CPSU)

Clemson University, Clemson, S.C. (CPSU)

(all the rest are memoranda of understanding)

College of the Virgin Islands, St. Thomas

Fairleigh Dickinson University (West Indies Lab), St. Croix, U.S. Virgin Islands

University of Florida, Gainesville

Tuskegee Institute, Alabama

Eastern Kentucky University, Richmond

Gulf Coast Research Lab, Ocean Springs, Miss.

Southern University, Durham, NC

Cave Research Foundation, Columbus, Ohio

Virgin Island Resource Management Cooperative, St. Thomas

Institute of Tropical Forestry, Virgin Islands National Park

Southern Appalachian Research/Resource Management Cooperative (10 regional universities and agencies)

University of West Florida, Pensacola

Memoranda of Understanding also exist between the SE Regional Office of NPS and the regional offices of U.S.G.S., U.S.F.W.S., and NOAA, the latter with specific reference to Synchronous Meteorological Satellites (SMS), Geostationary Operational Environmental Satellites (GOES), and Command and Data Acquisition Station.

Southwest Region

University of Arkansas, Fayetteville

Texas Technological University, Lubbock

University of New Mexico, Albuquerque

University of Texas, Austin

Texas A&M University, College Station (WASO)

Northern Arizona University, Flagstaff

Eastern New Mexico University, Portales

Cave Research Foundation, Columbus, Ohio

Pacific Northwest Region

University of Washington, Seattle

Oregon State University, Corvallis

University of Idaho, Moscow

Western Region

University of Nevada, Las Vegas

University of California, Davis

University of Hawaii, Honolulu

University of Arizona, Tucson

Alaska Region

University of Alaska, Fairbanks